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A Water Wheel in the Nile Delta.

PRIMITIVE METHODS OF IRRIGATION EMPLOYED IN EGYPT AT THE PRESENT DAY. – **[See page 184.]**

The Vibrations of Telephone Diaphragms—II*

An Experimental Investigation

By Charles F. Meyer and J. B. Whitehead

Concluded from Scientific American Supplement No. 1915, page 170

DIAPHRAGM B.

Another receiver, designated as No. 122 *W*, also of the bipolar type, was next investigated. Its characteristics were: Total diameter of diaphragm 5.51 centimeters (2.17 inches). Inside diameter of clamping ring 5 centimeters (1.97 inch). Thickness of diaphragm over enamel and varnish 0.028 centimeter (0.011 inch). Thickness bare at edge 0.023 centimeter (0.009 inch). Distance between pole pieces and plane of clamping ring of diaphragm about 0.03 centimeter (0.012 inch).

It seemed desirable to ascertain whether the mirror had any noticeable effect on the form or range of the oscillation, so in this set of exposures the current was kept as nearly constant as possible for each plate. One section was exposed with a load of 8 milligrammes of wax placed on the diaphragm as near to the mirror as possible, and the other section was exposed without the load. Some of the photographs are reproduced in Fig. 5. In none of these is there any noticeable difference in wave form when the load is on and off, nor is any difference shown in the other photographs which are not reproduced. The traces were all carefully measured. The differences in width are of the order of the errors of measurement, which range from, say, 5 per cent when the traces are as wide as those for 820~ to 15 or 20 per cent for narrow traces, as for 1440~. The measurements on the same trace usually check up to one or two per cent if the range of the trace is a centimeter or more, but in measuring traces of different photographic intensity the accuracy is probably not so great. The figures for 820~ show an

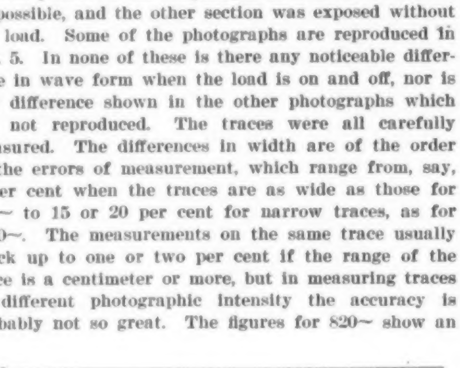


Fig. 11.—Resonance Curve for Diaphragm A. Giving the Relation Between Frequency and Range of Oscillation for a Constant Current.

increase of 8 per cent for the loaded case over that for no load; this may be a real effect.

Fig. 12 gives the resonance curve as nearly as it can be plotted from the scant data obtained for this diaphragm. Frequency is plotted as abscissa, and the ratio of diaphragm oscillation to current as ordinate. If we assume the linear relation of current and diaphragm oscillation for a fixed frequency this gives the same curve as Fig. 11 to within a constant factor. We see that the minimum before the first maximum is again present, and in a more marked degree than for the first diaphragm. The maximum ordinate is about five times that at the minimum as before, but only three times that at the lowest frequency. However, it is not entirely certain that the maximum comes at 820~ as drawn. When watching the light spots this appeared to the eye to be about the maximum, and so the photograph was made at this frequency. If more points had been obtained they might have shown that the maximum really lies at a somewhat different frequency, and has a 10 or 20 per cent greater value. The curve shows no further resonance points up to the highest speed the machine attained, but they doubtlessly would have been found if it had been possible to go high enough. This diaphragm had approximately the same characteristics as the first, so if we apply Rayleigh's formula we again get 890 as the natural frequency, the agreement with the experimental value being somewhat better this time.

GENERAL OBSERVATIONS.

More diaphragms, and diaphragms of different characteristics might have been examined by the method here used, but it was thought that before the investigation was extended in this direction further knowledge should be obtained about the motion of some one diaphragm. It was pointed out above that when a circular plate is vibrating freely, the nodes are circles and diameters.[4] In the case of a clamped diaphragm this means that the nodes may be located as shown in Fig. 13. These drawings are for the five lowest modes of vibration and are given in the order of ascending frequency. We may expect that in the case of a telephone diaphragm some of these types of vibration will be present. It cannot be said in advance which ones will occur nor to what extent they will do so. This depends on the frequency of the impressed force and on the way in which it is applied, and can only be found by experiment. Hence we may suppose that by fixing

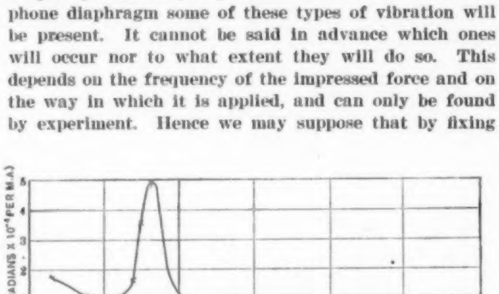


Fig. 12.—Resonance Curve for Diaphragm B.

a mirror in one spot (e. g., over the perpendicular bisector of the pole pieces) we cannot learn all that should be known about the motion of the diaphragm, and this is borne out, even to a more marked degree than was expected, by visual observation of the spot of light at certain frequencies. The spot ordinarily vibrated in a horizontal direction. This is what would be expected if the vibration consisted of a motion of the diaphragm as a whole (Fig. 13*a*), or if there existed an internal circular node (Fig. 13*d*). We may refer to this as a "circular" vibration. At certain frequencies the spot of light vibrated, not horizontally, but obliquely. An oblique motion would be produced if there were superimposed on the circular vibration a vibration having one or more diameters as nodes, as in Fig. 13 *b c*, or *e*. We may speak of this motion as a "diametral" one. The mirror need not be located on a node to show this component, but would do so to some extent if it were located anywhere except on a loop. This component cannot be symmetrical about the center of the diaphragm.

It is not at once evident why the diametral vibration should be introduced at all. If we assume the complete symmetry of the diaphragm about its center, and of the pole pieces about the diameter bisecting them perpendicularly, there is no reason to expect it. We must look for a lack of symmetry somewhere. The mirror on the diaphragm suggests itself, but the weight

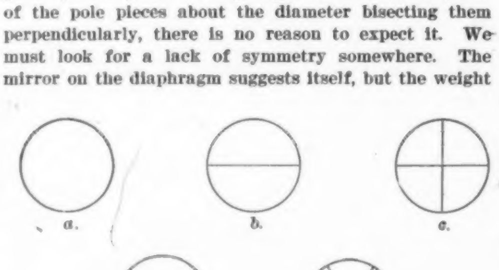


Fig. 13.—Representing the Five Lowest Modes of Free Vibration of a Circular Diaphragm.

a.—The boundary as the only node—diaphragm vibrating as a whole.

b.—One diameter as node—the two halves of the diaphragm vibrating in opposite phase.

c.—Two diameters as nodes—adjacent quadrants are in opposite phase.

d.—Two circles as nodes—the inner and outer areas are in opposite phase.

e.—Three diameters as nodes—adjacent sectors are in opposite phase.

of the mirror was only 4 milligrammes, and it seems improbable that so small a load could be responsible for the vibration. It was thought that some sort of asymmetry must exist in the poles, and if this were the case then a rotation of these behind the diaphragm ought to make the nodal diameter rotate in the diaphragm, keeping a fixed position with reference to the poles. This would allow an exploration of the motion, so to speak, around the diaphragm without moving the mirror or the diaphragm itself. A receiver (122 *W*) exactly like the one used with diaphragm "*B*" was fitted up to allow the rotation of the poles. With this instrument it was found that the diametral component recorded by the spot of light changed markedly as the pole pieces were rotated; it passed from zero through a maximum and back to zero in about half a revolution. But it was also noticed that there was a decided change in the intensity of the sound as the rotation took place, which, of course, should not exist if the diaphragm were symmetrical and the nodal diameter were merely being turned therein. Moreover the maximum diametral components recorded by the image coincided with the maximum sound, so that possibly the main thing shown was that the amplitude of the diametral vibration of the whole diaphragm depended on the orientation of the diaphragm over the poles. Three things presented themselves in explanation of this fact: First, mechanical imperfections in the rotating part might cause the poles to approach the diaphragm in certain positions and recede at others. Second, the influence of the weight of the mirror might make one direction in the diaphragm different from another. Third, the grain of the diaphragm may be the cause. This was suggested by Kempf-Hartmann[5] as a possible cause of asymmetry. Some rough experiments were at once instituted to decide between these three possibilities, and it is certain that mechanical imperfections

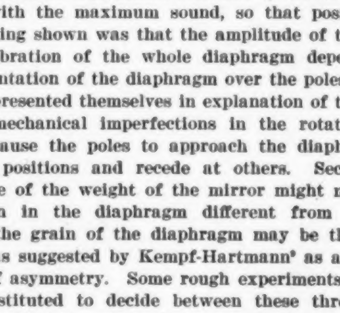


Fig. 14.—Electrical Connections in Working With the Transmitter.

play only a small part if any at all. No decision could be made between the influence of the mirror and grain, but it is thought that this can be done in the future. If it develops that the orientation of the grain in the diaphragm over the poles plays an important part in determining to what extent the diametral vibrations are introduced, it would appear to be a matter of some importance.

Whether these vibrations are a help or a hindrance in the transmission of speech it is difficult to say. It is generally considered that the fundamental tone of the diaphragm falls within the range of the principal frequencies of the voice, and this is borne out by comparison of the curves of Figs. 11 and 12 with the data given on the frequencies for different sounds. The amplitude of the circular vibration is small between the fundamental and the next higher resonance tone. Sounds of certain pitch are, therefore, very much magnified in relation to others. The frequencies of the vibrations with one diameter and two diameters as nodes lie below the frequency for the second circular vibration. From the observations discussed above it appears that a telephone diaphragm may be made to take up these nodes of vibration by properly orienting it over the pole pieces or by properly loading it. Now, might it not be possible by deliberately introducing the diametral vibrations, both in transmitter and receiver, and choosing the sizes of the diaphragm in such a manner that the maxima of the resonance for the one diaphragm, coincide with the minima of the resonance for the other, to maintain more nearly the relation between the amplitudes of sounds of different frequencies?

WORK ON THE TRANSMITTER.

Arrangements and Apparatus.—For the transmitter

* A paper presented at the twenty-ninth annual convention of the American Institute of Electrical Engineers, Boston, Mass., and published in the *Proceedings* of the Institute.

[4] Winkelmann's "Handbuch der Physik, II," p. 372, ed. 1909. Rayleigh, "Sound," Vol. I, pp. 331 and 366.

[5]. Kempf-Hartmann. *Annalen*, VIII, p. 492, 1902.

the general problem is similar to that for the receiver, namely, to exert an oscillating force of known form on the diaphragm and record the vibration produced by it. As in actual use the transmitter is acted on by sound waves, the most natural thing would be to use these for the impressed force, but experimental difficulties arise which make this impracticable. It is difficult, if not impossible, to get a source of sound which is sufficiently loud, and at the same time gives a pure tone of which the pitch and intensity may be easily varied and measured over a wide range. Moreover, when working with sound sources in an inclosed space, such as the room of a laboratory, there are always standing waves set up between the walls of the inclosure which would introduce a further uncertainty in determining the intensity of the sound which is incident upon the transmitter diaphragm. For these reasons no attempt was made to use a sound source. From the work on the receiver the conclusion seemed justified that the pull produced on the diaphragm by the receiver magnet is nearly harmonic for a harmonic current, and the amplitudes of the force and current are proportional if the current is not too great. It was accordingly decided to use a receiver magnet for producing the force acting on the transmitter diaphragm, as this allows the frequency and amplitude to be easily varied and measured. The magnet of a receiver was mounted rigidly in front of the transmitter. A small iron disk was shellaced onto the diaphragm to have some magnetic material for the magnet to act on, as the transmitter diaphragms themselves are of aluminium. The necessity of using the disk and the fact that the magnet produces a central force instead of a distributed one, as does a sound wave, are disadvantages of this method. (The weight of the disk was 0.81 gramme.)

The current from the alternating current generator was passed through the coil of the receiver magnet, and the current wave recorded on the oscillograph. For recording the vibration of the diaphragm the mirror method would have had certain advantages, but with a system as stiff as the transmitter the amplitude would not be great enough. Current from a storage battery was passed through the transmitter and the second vibrator of the oscillograph in series, and the variation of current in the transmitter due to the vibration of the diaphragm was recorded on the same photographic plate on which the curve of the current through the magnet was recorded; the variation of current in the transmitter was taken as a measure of the oscillation of the diaphragm. The electrical connections are shown in Fig. 14. In one electrical circuit which will hereafter be referred to as the "magnet circuit," the high frequency generator *G*, the oscillograph O_1, the coil on the magnet *F* and the resistance *R* are in series. In the other circuit which will be called the "transmitter circuit," the current flows from the storage battery *B* to the diaphragm *D* through the carbon granules box of the transmitter *C* to the oscillograph O_2, and through the milliammeter *A* back to the battery. The battery consisted of three storage cells; the voltage remained constant at 2.9 volts throughout. The two circuits had the point *E* in common at which they were connected to earth. The action of the apparatus is simple. The alternating current in the coil of the magnet *F* causes the diaphragm *D* to vibrate. Before the beginning of the vibration the current in the transmitter is steady and can be read on the milliammeter *A*. This steady current causes a steady deflection of the oscillograph O_2. When the motion of the diaphragm begins the current undergoes variations which are recorded by O_2. During the time of making an exposure the milliammeter is shunted so as to do away with all possible self induction in the transmitter circuit.

PHOTOGRAPHS AND MEASUREMENTS.

Some of the photographs are shown in Figs. 6 and 7. (See p. 169). The trace on the left shows the current in the magnet coil. The zero line is not shown, but would traverse the middle of the trace as this is due to a simple alternating current. The straight dark line on the right gives the line for zero current in the transmitter. The trace to its left gives the variation of current through the transmitter when the diaphragm is oscillating. That is, the distance from the zero line to the trace at any point gives the instantaneous value of the current, and the difference between the maximum and minimum distance gives the range of oscillation of the current. The frequencies are given to the right.

On the plates for 600, 700, 940 and 1014 cycles, and on most of the plates not reproduced, the traces are pointed for maximum current (granules compressed) and flat for minimum current. In these cases the steady current line runs nearer the minimum than the maximum. This was shown by an asymmetrical broadening of the light spot toward the left when the exciting current was turned on, and also by a rise in the reading of the milliammeter *A*. In plate 6 (see p. 169), namely, for 288 cycles, this is reversed. The points are for minimum current and the flat side for maximum. In this case the steady current line runs nearer the maximum, the broadening being asymmetrical to the right, and correspondingly, the milliammeter fell on making the exciting current. The plate for 1350 cycles gives a more symmetrical trace of 288~, but showed the

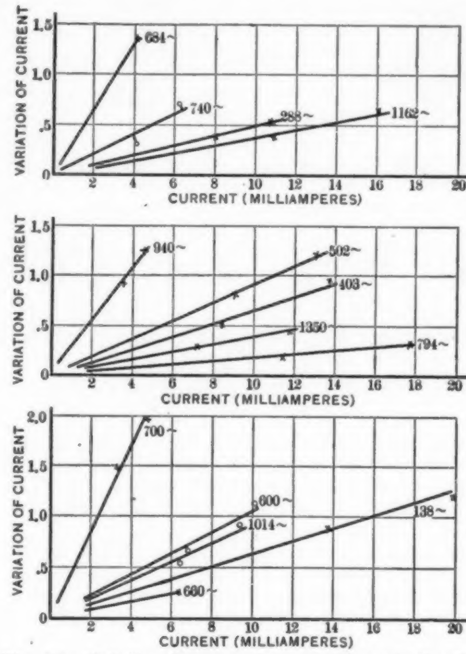


Fig. 15.—Relation Between Current Through the Coil of the Magnet, and the Variation of the Current Through the Transmitter.

same anomalous behavior in the broadening of the light spot toward less current, and the dropping of the milliammeter. These two plates were taken one after the other. This anomalous condition had been observed visually on one occasion when observing the oscillations by means of a ground glass and a rocking mirror, but the transmitter had gone back to its normal condition before a photograph was obtained. After this no amount of tapping and exciting would bring it back. The plates in question were obtained when at the end of a series of exposures this condition was found to exist accidentally. After these two plates the transmitter returned to its normal state. Later one more anomalous trace was obtained at 660, but this does not fit in well with the others. The peculiarity did not seem to occur at any definite frequency, but seemed to depend entirely on the arrangement of the granules, for when once present it showed over a wide range of frequency, and when absent the same frequency could be gone over with normal results. It is not to be confused with ordinary "packing," but may be closely allied to it. The traces for the transmitter in general show a great deal more distortion than do those for the receiver. The actual range of force on the diaphragm is considerably less for the transmitter, as the air gap between the magnet and disk is greater, and the amplitude of the current in the magnet is less. Plotting for each frequency the current in the magnet as abscissa, and the variation of current in the transmitter, per milliampere of steady current as ordinate, we get the curves of Fig. 15. This relation between the two is seen to be approximately linear. The point

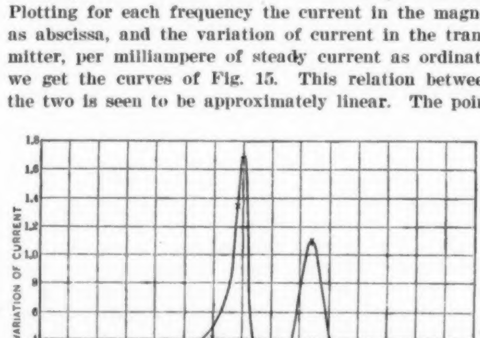


Fig. 16.—Resonance Curve for the Transmitter.

farthest out usually shows a somewhat steeper slope, but in several cases the reverse is true. The accidental errors due to changes in the transmitter are, of course, great, so a straight line running between the two points was considered a fair locus for the curve. In Fig. 16 a curve is plotted having frequencies as abscissas, and as ordinates the variation of current in the transmitter per milliampere of steady current, when the current in the magnet has a constant value of four milliamperes. This is the resonance curve for the diaphragm. The points all fall fairly well into line except the one for 660~, which is the one exposure made when the transmitter was for the second time in the anomalous state. The two plates obtained when it was for the first time in this state fall into line very well. The resonance curve certainly does not include the point at 660~, as the light spots were watched visually, when the granules were in normal condition, and no drop in amplitude at that frequency was ever noticed. The light spots were watched time and again as the generator accelerated or came to rest; and it was easy to see the marked continuous rise and fall in the width of the oscillation.

We notice in the curve the slight fall before the first maximum which was present in the receiver diaphragm curves, and is probably due to the losses in the magnet. Next the sharp maximum at 700, the minimum at 800, the second maximum at 940, and after this the drop to a fairly constant value. It is regretted that the investigation could not be pushed above 1350; but at higher frequencies conditions became very unsteady, especially is this true of the average current through the transmitter. It is a great surprise to find such sharp maxima in the curve, and two so close together. The ordinate of the first maximum is seen about eight and a half times that at the minimum, and six and a half times that at the lowest frequency; at the second maximum about eighteen times that at the minimum just before it, and about four times that at the lowest frequency. The location of the fundamental vibration at 700 cycles is in good agreement with Gati's work.

The first resonance of the diaphragm we would naturally suppose to be due to its vibration as a whole. The second may be introduced by one of the so-called damping springs. The diaphragm in most modern transmitters, and in the one here worked with, is held in place by two pieces of spring steel about ⅜ inch wide, 1½ inches long and 0.01 inch thick. These have rubber tips on the ends. One presses against the diaphragm at the edge; and the other one, some distance in toward the center. Now the point where the second one presses is more firmly supported than the points in its vicinity, so the second resonance may be due to a vibration of irregular configuration with this point lying on a nodal line. If this is the case one of the actions of the damping springs is just the opposite to that commonly supposed. According to Kempster B. Miller:[10] "The object of these damping springs is to prevent too great an amplitude of vibration of the diaphragm, and also to keep it from vibrating in separate parts instead of as a unit." The inside damping spring may also have considerable influence in raising the fundamental period of the diaphragm as it adds to its stiffness. It should be possible to settle these questions by placing both springs on the edge and taking another resonance curve.

SUMMARY OF RESULTS.

Photographs have been obtained showing the vibration of receiver diaphragms when approximately harmonic currents are passed through the receiver. These show considerable distortion at some frequencies and very little at others. At any one frequency the distortion is less for smaller currents. This is what would be expected from *a priori* consideration.

An approximately linear relation has been shown to exist between current and amplitude of oscillation of the diaphragm over the range of work, which extends well beyond that of practice. Resonance curves for two receiver diaphragms have been plotted giving quantitative data of the influence of the natural period of the diaphragm.

Diametral vibrations of the diaphragm were observed in cases in which they would not have been expected from the apparent symmetry of the instrument. The orientation of the diaphragm over the pole pieces was observed to have a marked effect. It has not been experimentally settled whether this is due to the mirror or the grain of the plate, but it is difficult to see how a mirror weighing only 4 milligrammes could cause the vibrations. It is suggested that by properly introducing "diametral" vibrations the transmission of speech might be improved.

Photographs have been obtained showing the variation of current in the transmitter when an approximately harmonic force acts on the diaphragm. These show a rather marked distortion even for the lowest exciting force used, which was very much lower than the lowest force used on the receiver diaphragm. These distorted curves may be just reversed from their normal form when the microphone is in a certain abnormal state.

An approximately linear relation exists over the range examined between the variation in current and the exciting force. The resonance curve of the transmitter is given showing very marked maxima and minima. The first maximum is attributed to the fundamental period of the diaphragm vibrating as a whole. The second maximum is attributed to the diaphragm vibrating in an irregular configuration on account of the damping springs.

[10] American Telephone Practice. 4th edition, p. 56.

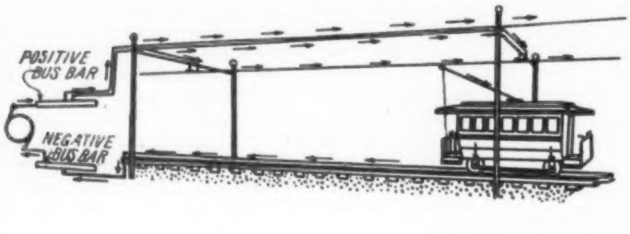


Fig. 1.—Single Trolley Railway, Showing Path of Current from Generator Through Positive Feeders, Trolley Wire, Car and Rails.

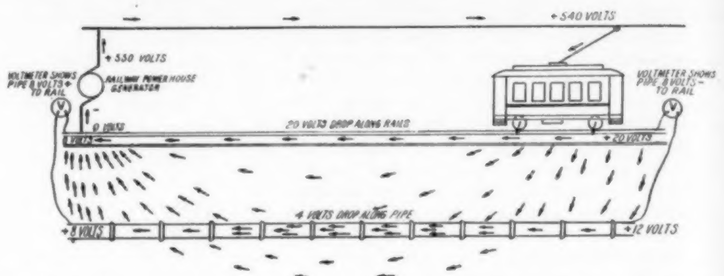


Fig. 2.—Diagram Showing Stray Railway Currents With Assumed Distribution of Potentials Caused by These Currents.

Electrolysis from Stray Currents—I*

Damage Caused to Underground Structures

By Albert F. Ganz, M.E., Professor of Electrical Engineering, Stevens Institute of Technology

DEFINITION AND THEORY OF ELECTROLYSIS.

Electric currents may be conducted in two ways, first, by metallic conduction, and second, by electrolytic conduction. Metallic conduction occurs when an electric current passes through a metal, and is characterized by the fact that no chemical change is produced in the conductor, the only effect being the production of heat. Where electric currents, therefore, pass through metallic conductors, such as copper wires, rails, or pipes, they produce no change in these conductors except to raise their temperature. Under all ordinary conditions stray electric currents found on underground pipes are not sufficiently large to appreciably heat these pipes. Under abnormal conditions pipes may however carry stray currents of sufficient magnitude to produce heating at moderately high resistance joints.

Electrolytic conduction occurs when an electric current passes through an electrolyte, and is characterized by the fact that the electric current is transmitted by a corresponding transfer of *ions* in solution, with the production of chemical decomposition at the electrode where the current enters and leaves the electrolyte. Electrolysis may therefore be defined as chemical decomposition produced by an electric current. Electrolysis is usefully applied in the arts for the refining of metals and for producing chemical compounds. I want to discuss here the destruction of underground structures caused by electrolysis from stray electric currents which reach these structures.

Chemical compounds in solutions of water constitute the ordinary electrolytic conductors. Pure water itself has such a high resistance that it may practically be considered a non-conductor. It is for this reason that an iron pipe full of ordinary city supply water does not have a lower resistance than the same pipe without water. Water is, however, readily made conducting by the addition of small amounts of salts, and conduction through water is therefore always electrolytic.

The following is a brief explanation of the theory of electrolytic conduction. When a salt is dissolved in water, some of the molecules separate or dissociate into two parts, one part having a positive electrical charge, and the other a negative electrical charge, and these parts are called *ions*. The metal parts or the hydrogen constitute the positive ions, and the acid parts the negative ions. For instance, copper sulphate, $CuSO_4$, when dissolved in water, dissociates into the positive metal ion, Cu, and the negative acid ion SO_4. An electric current is transmitted through an electrolyte by the transfer of these ions. The electrode by which the current enters the electrolyte is called the *anode*, and the one by which the current leaves is called the *cathode*. The metal or hydrogen (positive) ions travel in the direction of the current and carry positive electrical charges to the cathode, and these metal ions, called *cations*, are deposited upon or are liberated at the cathode. The acid (negative) ions travel against the current and carry negative electrical charges to the anode, and these acid ions, called anions, will corrode the anode if it is a metal which combines chemically with these anions. The cathode is not corroded. With an electrolyte of copper sulphate dissolved in water, a copper anode corrodes into copper sulphate and dissolves, while metallic copper is deposited upon the cathode. If the electrolyte is common salt dissolved in water, the anions are chlorine, and an iron anode would be corroded, the iron forming ferrous chloride; the *cations* are sodium, and these would decompose the water present and liberate hydrogen at the cathode. These examples furnish an illustration of the fact that the corrosive action of the current results in supplying the electrolyte with an equivalent of the amount of salt decomposed by the current, so that the electrolyte is continually replenished with salt and its electrolytic conducting power is thereby maintained. This salt will contain metal ions of the anode or hydrogen, and may be different from the original salt which started the action.

Street soils when entirely dry do not conduct electric currents. Under ordinary conditions, however, street soils contain considerable water with salts in solution, generally chlorides, and this makes them electrolytic conductors. When an electric current passes through soil it therefore does so by electrolytic conduction and by corresponding chemical decomposition of the electrodes. Where an electric current leaves an iron pipe for soil it corrodes the iron by this action of electrolysis. It has been claimed in the past that soils may conduct metallically, but this has been disproved and it is now recognized that conduction of electric current through soil is always electrolytic.

The rate at which ions are liberated at the electrodes is proportional to the current strength. With an oxidizing anode, such as iron or lead, the mass of anode corroded by one ampere in one second is equal to the electrochemical equivalent of the metal of the anode. This is 0.00029 gramme for iron (ferrous). From this mass of iron corroded by one ampere in one year is $0.00029\times60\times60\times24\times365\times0.002205=.20$ pounds (approximately) The electrochemical equivalent for lead is 0.0010718 gramme, and the mass of lead corroded by one ampere in one year is $0.0010718\times60\times60\times24\times365\times0.002205=74$ pounds (approximately).

The separation of the metal or hydrogen ion from the electrolyte at the cathode absorbs energy from the electric circuit, and generally produces an electromotive force in the opposite direction to the current. The oxidation of the anode supplies energy to the circuit and generally produces an electromotive force in the direction of the current. If the oxidizing anode is of the same metal as is being deposited upon the cathode, and if the electrolyte is the same at the anode and cathode, then there is no resultant electromotive force due to the electrochemical actions, and the only electromotive force consumed is that due to the resistance of the electrolyte in accordance with Ohm's Law, exactly as with a metallic conductor. If the metal deposited at the cathode is different from that oxidized at the anode, or if hydrogen is liberated at the cathode, or if the electrolyte at the cathode is not of the same composition or density as at the anode, then there will be a resultant electromotive force, which may be either in the same or in the opposite direction as the current. It has been assumed by some writers in the past that no corrosion from electrolysis can take place if the voltage between two metallic conductors in soil, such as between pipe and rails, is less than 1.5 volts, because this is the dissociation voltage of water. This, however, is entirely wrong, and it has been proven by investigations and is now generally recognized that the amount of corrosion produced by electrolysis is independent of the voltage, except in so far as this determines the amount of current flowing, and that the smallest fraction of a volt can produce corrosion from electrolysis under suitable conditions.

SOURCES OF STRAY ELECTRIC CURRENTS.

Stray currents are electric currents which have leaked from grounded electrical distribution systems and flow through ground and through underground structures. Grounded telephone and telegraph lines produce electric currents through ground of such very small magnitudes that their effects upon underground piping systems can be neglected. Direct-current electric lighting systems in which the distribution is on the Edison 3-wire plan with the neutral conductor grounded, are in American practice provided with such large neutral conductors of copper that practically no stray currents are produced from such systems. This grounding of the neutral in Edison 3-wire systems is to serve as a safeguard and is not for the purpose of using the ground to carry current. Alternating-current lighting systems where grounded generally also produce only small stray currents, and the electrolytic effects from these small stray alternating currents are always negligible.

Electric railways using the running tracks for return conductors often produce comparatively large stray electric currents through ground, and these are the only source of stray currents which need be considered in practice. Direct current is almost exclusively used for such electric railways and it is the common practice to supply current to the cars from an overhead trolley wire or from a third rail, and to return this current to the power station through the running tracks, supplemented where necessary by return feeders. A single trolley electric railway is shown diagrammatically in Fig. 1, in which the path of the electric current from the positive terminal of the generator through the circuit and back to the negative terminal is shown. The running tracks consist of rail lengths about 40 feet long, and these are mechanically fastened together by fishplates which consist of steel plates bridging across the rail ends and bolted to both rails. Such fishplates while mechanically fastening the rail together, do not form good electrically conducting connections between the successive rail lengths. For this reason, copper wires or straps, called rail bonds, are generally used to bridge across the abutting ends of the rail lengths for the purpose of affording a good electrically conducting path between successive rail lengths. The two rails of a single track road, or the four rails of a double track road, are also generally connected together at frequent intervals by cross-bonds so that the two or the four rails may be available for the return of current. Instead of using copper rail bonds, the rail ends are sometimes welded together, or soft steel plates are welded across each side of the abutting rail ends, thus forming both a strong mechanical and a good electrically conducting connection between the successive rail lengths. A well bonded railway track should have a conductivity not less than 80 per cent of the equivalent conductivity of continuous rails. To give some idea of the relative conductivity of steel rails, it may be stated that a single rail weighing 90 pounds per yard, which is a size commonly used where the traffic is heavy, has about the same conductivity as a copper wire one inch in diameter. Thus the two rails of a single track line or the four rails of a double track laid with 90-pound rails and well bonded afford a good conducting path for electric current.

In the simplest form of single trolley railway, already shown in Fig. 1, the rails are connected to the negative terminal of the generator at the power station, and the only path for current to return to the power station is by way of the running tracks. If the running tracks are laid upon wooden ties above ground with broken stone for road ballast, as is common on steam railroads which run on their own right-of-way, the rails do not come in direct contact with ground, and the return current will be practically confined to the running tracks. If, however, the running tracks are laid below ground so that the top of the rails is on the level of the surface of the street, as is common in cities, then the rails will be exposed for a considerable area to contact with soil. If the tracks are laid on a concrete base a considerable area of the rails will similarly be in contact with the concrete. Since both damp soil and damp concrete are under ordinary conditions conductors of electricity, part of the current returning through the rails will shunt from the rails through the surrounding soil, as is illustrated diagrammatically in Fig. 2. It will be seen that with the usual connection of positive terminal of the generator to the trolley wire, and the negative terminal to the rails at the power station, the current will leave the rails for ground at points distant from the power station, and return to the rails in

* A lecture delivered before the American Water Works Association at Louisville, Ky., June 6th, 1912.

the neighborhood of the power station in its path back to the negative terminal of the generator. Since every electric circuit must be completely closed, all current escaping through ground must again leave ground to return to the dynamo so as to complete the electric circuit. Where underground metallic structures, such as gas or water pipes, lie in the ground in the path of these stray currents, and where these pipes have electrically conducting joints, such as lead calked joints or screw coupling joints, current will flow from ground to such pipes and flow largely on such pipes in a direction toward the power station. In the neighborhood of the power station this current will leave the pipes to return to the negative terminal of the generator, as shown in Fig. 2.

If the negative terminal of the generator or the negative bus-bar is connected to the rails at other points than at the power station, by means of negative return feeders, then at such connection points the rails will be rendered negative in potential to ground, and currents will tend to flow from underground pipes through ground to return to the rails in the neighborhood of these connections. Stray railway currents on pipes will therefore tend to leave these pipes to return to the rails in all regions where these rails are connected to return feeders.

It must be noted that while ordinary soil is a conductor of electricity, compared with metals its electrical resistance is enormously high; for instance, the resistance between the opposite faces of a foot cube of ordinary soil may measure anywhere from 10 to 1,000 ohms, depending upon the amount of moisture and the amount of salts in the soil, while the resistance of a foot cube of iron is equal to about 0.0000004 ohm; if, therefore, we take an average value of 100 ohms for the resistance of a foot cube of soil, it is seen that soil has a resistance which is of the order of 250,000,000 times as great as a body of iron of the same dimensions; that is to say, the conductivity of iron is 250,000,000 times as great as that of ordinary soil. It would seem from this that current would flow almost entirely on the well conducting rails and none would pass through the high resistance ground. Resistance, however, varies directly as the length and inversely as the cross-section of a conductor, and with the large surface of rails exposed to the ground, the cross-section of the path of the current through ground is enormously great compared with the cross-section of the path of the current through the rails. As a matter of practice it is found that where the rails alone are used for the return of current, frequently a considerable portion of the total current actually leaks from rails through ground.

From the above considerations it will be seen that the leaking of current from the rails of electric railways, producing stray currents through ground and on underground piping, does not constitute a source of loss to the railway company, as for instance would be the case with leakage of gas or water. On the contrary, by allowing the current to return by ground and underground pipes as well as by way of the rails, the total conductivity of the return circuit is increased, and the voltage loss in the return of this current is decreased, so that there is an actual saving of power for the railway company.

GENERAL EFFECTS OF STRAY ELECTRIC CURRENTS ON UNDERGROUND PIPING.

The current flowing through the rails from the trolley cars back to the power station produces in these rails a drop in potential; that is to say, points in the rails away from the power station have a positive potential with reference to the rails at the power station. Since potentials are measured relatively it is convenient to consider the negative terminal of the dynamo, which is assumed connected to the rails at the power station, as at zero potential. The distribution of potentials in the rails of a simple electric railway system and in the underground piping is illustrated in Fig. 2, in which convenient values have been assumed. It will be noted that the stray current causes the underground pipes to be negative to the rails at points away from the power station, and positive to the rails near the power station. It is also seen that the negative potential of the pipe, plus the drop on the pipe, plus the positive potential of the pipe, equals the drop in the rails. In the case assumed, there is a potential difference of 550 volts maintained at the power station; of this, 10 volts is lost in the trolley wire, 520 volts is used by the motors of the cars, and 20 volts is left to bring the current back to the power station. If the negative bus-bar and the rails at the power station are considered as at zero potential, the rails at the car in the assumed case will have a potential of plus 20 volts. Thus, for practical purposes, the ground with its underground pipes is subjected to a potential difference of 20 volts, and the amount of stray current produced is that due to these 20 volts. If the rails are laid in the usual way, that is, in contact with ground, the 20 volts in the rails will send some shunting current through the ground and through the underground pipe as shown in the diagram. Under the assumed conditions, there is a drop of 8 volts from the rails to the pipe near the car; a drop of 4 volts in the pipe itself, and a drop of 8 volts from the pipe through ground to the rails at the power station. It is therefore seen that it is the potential difference or drop in grounded rails caused by the return current which is the cause of stray currents through ground. Attempts should therefore be made to keep the potential difference or drop in rails as low as practicable in order to keep stray currents through ground down to a minimum.

From the explanation of metallic and electrolytic conduction given in the first part of the paper, it will be understood that where stray currents flow on underground pipes they do no harm except where they leave the pipes to flow to the surrounding soil. At such points corrosion of the iron from electrolysis will take place, and theoretically there will be a loss of 20 pounds of iron per year for every ampere of electric current leaving the iron. Some have assumed that with the low densities at which current generally leaves underground pipes, little or no corrosion is produced. A number of experiments made by the writer have clearly shown, however, that even when current leaves iron for street soil at an extremely low density, corrosion is produced which is at least equal to, and frequently greater than, the theoretical amount. This increase of the actual over the theoretical amount is undoubtedly due to secondary chemical reactions set up by the action of electrolysis.

The underground structures, which are most likely to be subjected to destruction from electrolysis caused by stray electric currents, are piping systems and lead cable systems. From what has been said above it will be seen that oxidation or corrosion of such pipes or cable sheaths will occur wherever current leaves the pipe or cable sheath for ground. In the simplest case, illustrated in Fig. 2, current flows from rails through ground to the pipes at points distant from the power station, flows along the pipes, and leaves the pipes to return through ground to the rails in the neighborhood of the power station. Where the current flows from the rails to ground, the rails will be corroded, and where the current flows from the pipes to ground, the pipes will be corroded. If the pipe line is a uniform electrical conductor, and the relative arrangements are as shown in Fig. 2, then the pipes will be corroded only in the neighborhood of the power station. If, however, the pipe line is not a uniform conductor, as for instance, if there are one or more high resistance joints in this pipe line, then the current on the pipe will shunt around such high resistance joints and produce oxidation or corrosion on one side of the joint. This action gives rise to joint corrosion which is frequently found. Where there are two or more underground piping systems it also often happens that current shunts from one piping system to another through the intervening soil, producing electrolytic corrosion where the current leaves the pipe. Such shunt currents are often caused by accidental high resistance joints in one of the pipe lines, and such shunting may occur anywhere and without reference to the location of the railway power station. Where a direct-current trolley railway system passes through a town which has an independent piping network, and where the power station supplying the trolley line is in some other locality, then if stray electric currents are produced from the trolley line where it passes through the town, they will flow on the piping system, making this piping system positive to ground and to rails in the direction toward the railway power station, and negative in the direction away from the railway power station. In this case electrolysis of the piping will be produced at the ends of the piping system toward the railway power stations.

Where current leaves a wrought iron or steel pipe for ground, the oxide of iron resulting from electrolysis is diffused through the soil and streaks of iron oxide can generally be found in the surrounding soil. Electrolysis of wrought iron or steel pipes usually results in pits which eventually go entirely through the wall of the pipe. It has frequently been found in practice in the case of gas pipes that where a service pipe lies in clay or other tightly packed soil, it may be pitted through in many places without giving any external sign of leakage because the soil surrounding the pipe maintains it gas tight. When cast iron is corroded by electrolysis, the oxide of iron mixed with graphite usually remain in place leaving the outside appearance of the pipe unchanged. This material resulting from electrolysis of cast iron usually has the consistency of hard graphite, and can be cut with an ordinary knife. There have been many cases in which a cast-iron main was carrying gas or water without any apparent leak, where a single blow with a hammer drove a hole right through the pipe. Here the electrolytic action had corroded the iron entirely through the pipe, and the oxide of iron had remained in place and, together with the surrounding soil, had prevented the pipe from leaking. Whether or not the mixture of iron oxide and graphite resulting from electrolysis remains in place so as to maintain a pipe, gas or water tight, depends upon the surrounding soil conditions. It is therefore seen that an underground piping system may be suffering severely from electrolysis without having given any outward sign of the damage. A physical examination with a test hammer is required in the case of cast-iron piping to establish definitely whether or not it has been damaged by electrolysis.

For a given current leaving an iron pipe, there is practically no difference in the amount of iron destroyed between cast iron, wrought iron and steel. The electrical resistance of cast iron is however about ten times as great as that of wrought iron or steel, and the usual lead joints in cast-iron pipes also have a resistance which is many times greater than the screw coupling joints usual with wrought iron and steel pipes. For these reasons a given voltage drop through ground will cause a much smaller current to flow on a cast-iron pipe than on a wrought iron or steel pipe, thus practically making cast iron pipes much less subject to electrolysis than wrought iron or steel pipes. The most frequent damage from electrolysis is found in the case of service pipes where these cross under trolley rails or other underground conductors to which they are positive. Examples of destruction of pipes by electrolysis which are often found in practice will be taken up in a later chapter under the heading of "Damage and Danger Produced by Stray Electric Currents on Underground Piping."

To be continued.

The Eighth International Congress of Applied Chemistry

A Survey of Some of the Principal Papers Presented

The abstracts of the seven hundred odd papers presented before the Congress fill no less than twenty-four octavo volumes. While it is obviously impossible to give a detailed account of all the communications made, short abstracts of some of the most important papers have been prepared and are collected here. A number of papers of special interests will also be published in more extended form in this and in later issues of the SCIENTIFIC AMERICAN SUPPLEMENT.

I. ANALYTICAL CHEMISTRY.

From the laboratory of the General Chemical Company three papers are submitted in this division. W. S. Allen and R. M. Palmer have developed a modification of the Gutzeit test for arsenic. It is found that with proper precautions an accurate determination of small quantities of arsenic in the presence of iron can be made provided that the iron is completely reduced to the ferrous state by means of stannous chloride.

The second paper, presented by W. S. Allen, is a plea for *A Rational Analysis of Sodium Nitrate*. The method advocated is that of Devarda, which consists essentially in reducing the nitrate to ammonia and collecting the latter in standard acid. The customary "Refraction" test is condemned.

A paper of special importance is the third contribution from the same laboratory: *An Exact Method for the Determination of Sulphur in Pyrites Ores.* The authors are W. S. Allen and H. B. Bishop. We quote from the summary of this paper:

"The method for the determination of sulphur in pyrites ore as now offered consists essentially of the complete oxidation and solution of a comparatively large sample by means of a solution of Br and CCl_4 followed by HNO_3; the reduction of the iron present by means of aluminium powder; and the cold precipitation of the $BaSO_4$ in a large volume by the slow addition of a dilute $BaCl_2$ solution.

"A large mass of data covering every detail of the method has been obtained which demonstrates fully the accuracy of the method and presents evidence as to the soundness of the principles involved and necessity for the observation of certain details.

"A number of experienced analysts and inexperienced men fresh from college have by the method accurately analyzed samples of pyrites ore, their duplicates almost invariably agreeing within a few hundredths of a per cent. Men who used the method for the first time obtained results agreeing closely with those by analysts of long experience with the method, evidencing its ease and simplicity."

A number of other important papers we must pass

over with a brief mention. The Chemists Committee of the U. S. Steel Corporation has contributed a detailed paper on *The Methods of the U. S. Steel Corporation for the Commercial Sampling and Analysis of Pig Iron.* P. H. Conradson is the author of three papers relating to the Examination and Study of Lubricating Oils.

F. P. Dewey, of the Mint Bureau, communicates a paper, *The Sampling of Gold Bullion*, in which he summarizes his conclusions as follows:

In sampling deposits of miscellaneous gold bullion weighing over 300 ounces:

There are various cases where either a chip or a drill sample may be satisfactory.

There are various cases where a drill sample is better than a chip sample.

Where the assayer is acquainted with the metal he may accept a chip or drill sample.

On an unknown bullion it is unsafe to accept any sample except a properly prepared dip sample.

In many cases, particularly of cyanide bullion, the composition of the metal interferes with the actual assaying and the bullion must be refined before one can expect to determine the gold accurately.

P. Mahler and E. Goutal report on the determination of carbon in steel and ferro-alloys by combustion in oxygen under pressure. S. W. Tarr describes a new bomb calorimeter.

II. INORGANIC CHEMISTRY.

In this section may be mentioned a paper by L. B. Cheney and G. W. Patterson on "Contact Sulphuric Acid from Brimstone. For the benefit of those among our readers who may yet be familiar with the details of modern sulphuric acid manufacture we may explain that the so-called "contact process" is based on the union of sulphur dioxide SO_2 with oxygen O under the catalytic influence of finely divided platinum. The sulphur dioxide is prepared by burning sulphur (brimstone) or pyrites (iron sulphide). The latter is the cheaper material, but contains impurities (such as arsenic) which "poison" the platinum, i. e., render it inactive, if they gain access to it. The experience of the authors using brimstone is thus summarized:

In this plant, using Louisiana brimstone for eighteen months, we have had no indications of "poisoning" and have not opened the converter. The temperature of gas entering the converter is kept constantly at 380 deg. Cent. and conversions are regularly 95 to 95.5 per cent. This low temperature means a decided saving in coal, and wear and tear on the preheater. During six months the average consumption of coal has been 21.8 pounds per 100 pounds of SO_3 made. We believe this to be a figure decidedly less than any Schroeder plant burning pyrites. An entrance gas of 6.5 to 7 per cent SO_2 is regularly used. During six months under the above conditions, the average make has been a little more than 6 tons of acid a day, and the average yield on sulphur fed to the burner 93.36 per cent. The plant can make a maximum quantity of 8 tons with a yield of 90 per cent. Comparison of cost sheets shows that by changing raw materials from pyrites to brimstone, we have reduced cost of manufacture nearly two dollars per ton of 98 per cent acid; that this reduction is due in part to minimizing losses from shut-downs for repairs in part to increased yields and in part to saving in coal and cost of upkeep.

We think that in this matter the results obtained by Patterson and Cheney are not wholly in accord with the experience of others.

D. H. Childs contributes a paper on the Action of Some Fluorine Compounds on Clay, Water, etc., which embodies results obtained in the course of an investigation of the possibility of making alumina commercially by heating clay with aluminium fluoride.

E. G. Clayton contributes a paper: *Phosphorous and Its Compounds, Considered Especially in Relation to the Manufacture of Matches.* We quote his concluding paragraph:

"The *desideratum* is still a combustible substance which will ignite at a temperature sufficiently but not dangerously low, which will be absolutely non-poisonous, will give off no injurious vapor or 'fume,' at any stage of the manufacture, and can be used with ease and safety in match works. It must mix evenly and well with the rest of the ingredients of a match-composition and without any disengagement of gas, should have no retarding effect upon the drying of the binding medium, and should yield a product as sensitive to friction as the best 'double-tip' match that ever was made. The match must be liable neither spontaneously to ignite at any reasonable temperature, nor to be affected detrimentally by a damp atmosphere. In conclusion, the new and ideal match-product must be cheaper, either absolutely, or relatively to excellence of quality and the advantages provided, than anything now to be had."

Other important papers in this division are: H. W. Gillett, *The Influence of Pouring Temperature on Aluminium Alloys;* Edward Hart, *Potash, Silica and Alumina from Felspar;* B. du Jassonneix, *Study of the Magnetic Properties of Alloys of Iron, Cobalt, Nickel and Manganese with Boron;* Bancroft and Lohr, *Tensile Strength of Copper, Zinc Alloys;* S. W. Parr, *A New Alloy with Acid Resisting Properties;* Utley Wedge, *The Sulphuric Industry in the United States;* W. Wilke, *Combination of the Contact Process with the Ordinary Lead Chamber or Tower Systems in the Manufacture of Sulphuric Acid.*

III. METALLURGY AND MINING.

R. C. Canby reviews the development of the American water-jacketed lead blast furnace.

A. S. Dwight describes the Dwight & Lloyd process of Roasting and Sintering. This is essentially a mechanical improvement of the so-called blast roasting or pot-roasting processes for agglomerating fine ores by the heat generated by internal combustion. Typical examples of this kind are the Huntington Heberlein, the Savelsburg Process, etc.

The special feature of the Dwight & Lloyd modification is that instead of material being prepared in huge lumps, as is ordinarily the custom, a thin slab of crisp "biscuit" is produced, which, while easy to break up into sizes suitable for smelting, is yet strong enough to withstand ordinary handling and to support the weight of the charge in the blast furnace. There are also other special features in the process.

Other important papers are: E. F. Eurich, *The Development of the Parkes* (lead desilvering) *Process in the United States;* F. Laist, *Chemistry of the Reduction Process in Use at Anaconda, Montana;* E. P. Mathewson, *The Development of the Reverberatory Furnace for Smelting Copper Ores;* J. J. Porter, *The Fuel Efficiency of the Cupola;* Utley Wedge, *The Sulphatizing Roasting of Copper Ores and Concentrates.*

IIIB. EXPLOSIVES.

Thomas M. Chatard discusses *The Misuse of Explosives; Its Extent and Prevention.*

"Noting the statement of a Portuguese revolutionist that 'bombs are cheaper and, in the hands of untrained people, more effective than other weapons,' this paper gives the results of a tabulation of 772 instances of the misuse of high explosives from 1903 to 1911, inclusive. In the United States alone, there were 213 explosions due to labor troubles and 238 Black Hand outrages, while 139 occurrences can only be ascribed to absolute lawlessness.

"This lawlessness is especially dwelt upon in the discussion of the results, which is confined to conditions existing in the United States. These conditions and the legal difficulties attending any legislation against and prosecution of such offenses, in this country, are particularly considered since any proposed remedy must be in conformity with them, if any practical benefit is to be expected, and the difficulties are greater here than abroad.

"The importance of the co-operation of the Sections of Explosives and of Law, of this International Congress, in securing adequate and satisfactory legislation and legal practice to this end is pointed out and the character and scope of this co-operation is indicated, while the need of such action is evidenced by the extent of this abuse and by the statements of prominent radical-socialistic leaders.

"The fundamental principle of the suggested legislation is that 'the unlicensed possession of any high explosive shall be a punishable offense, without reference to the intentions of the transgressor' and instances of such laws are given. A plan of a licensing system is outlined with examples of its practical working. 'It is prevention, not punishment, that is to be sought for' and this can best be obtained by enacting reasonable laws, satisfactory to legitimate business, and then rigidly enforcing them."

B. Flurscheim, Reports on the New High Explosive, Tetra-Nitro-Analin.

H. Hibbert contributes a paper on the preparation, the crystalized structure and physical properties of the two forms of solid nitro-glycerin. He summarizes his conclusions as follows:

1. It has been shown that solid nitro-glycerin exists in two forms, a labile and a stable isomeride possessing the following freezing and melting points:

Labile Form.	Stable Form.
F.P. 1.9 deg. Cent.	F.P. 13.0 deg. Cent.
M.P. 2.0 deg. Cent.	M.P. 13.2 deg. Cent.

2. Methods for the preparation of both isomeric forms have been developed and their various physical properties, solubility in solvents, sensitiveness to shock, crystallographic structure, the conditions under which one is converted into the other, and the influence of metallic salts in effecting such conversion have been investigated. Photomicrographs of both isomerides have also been prepared.

3. The substitution of potassium for sodium nitrate in the "dope" employed in making dynamite would presumably give a product freezing at a lower temperature, since with the former salt there is no tendency toward the formation of the higher-melting stable isomeride, although we are not aware of any observations indicating that dynamite made with commercial saltpeter is more difficult to freeze than that made with sodium nitrate.

4. The extraordinarily far-reaching analogy between the isomeric forms of nitro-glycerin and benzophenone has been commented upon and the evidence pointed out in favor of regarding the isomerism as "physical" rather than "chemical."

A. L. Robinson contributes a paper on *Detonator Troubles Experienced in the Construction of the Isthmian Canal.*

IIIC. SILICATE INDUSTRIES.

C. F. Binns and C. H. Makeley summarize their paper on the *Coloring Power of Iron Compounds in Burnt Clay* as follows:

1. It is not possible to produce red colors in burned clay by the use of pulverized iron bearing minerals, however finely they may be ground, but buff tones are produced under the influence of alumina and at a temperature at which the clay approaches vitrification. These buff colors are apparently due to the blending of a multitude of minute brown specks.

2. Red colors are the result of a precipitation of a colloidal iron compound in the clay mass. This precipitation apparently results from a solution of ferrous sulphate, which is itself the result of the oxidation of pyrite, either becoming oxydized with the separation of limonite or meeting with carbon dioxide in some form with the resulting precipitation of ferrous carbonate. This is the only way of explaining a statement made by Professor Orton, that "as good a red color may be developed from a clay containing its iron as ferrous carbonate as from ferric hydroxide." Siderite does not decompose under ordinary conditions and in the finely ground form no red is produced.

3. Pyrite is responsible for several phenomena. As already stated it is the parent of other forms of iron and while it is true as stated by Orton that the granules of pyrite "are never small enough to produce a red color," it is also true that pyrite is extremely susceptible of oxidation. Unless the clay containing this mineral is dried very rapidly ferrous sulphate and ultimately ferric hydroxide will be found. There are examples of this in the specimens shown; in fact, in these there is the actual birth of a red clay.

4. Alumina is undoubtedly responsible for the production of buff colors and in this the opinion of Seger is confirmed. At the same time it must be admitted that the effect of alumina, added, as in these experiments, in the pure form, may be different from that of combined alumina. Possibly the different behavior of clays with a similar content of alumina and iron may be accounted for in this way.

Other interesting papers are one by A. V. Bleininger on *The Effect of Electrolytes Upon Clay in the Plastic State;* George W. Coggeshall and Allerton S. Cushman on *The Production of Available Potash from the Natural Silicates;* Robert L. Frink on *Causes of Breakage in Glass Manufacture and Method of Differentiating Chemico-Heterogeneic Strains from Cooling Strains;* A. J. Phillips and A. A. Klein on *Magnesia in Portland Cement;* W. C. Reibling and F. D. Reyes on *The Physical and Chemical Properties of Portland Cement;* Walter A. Schmidt, on *The Control of Dust in Portland Cement Manufacture by the Cottrell Electrical Precipitation Processes.*

IV. ORGANIC CHEMISTRY.

Of chief interest, perhaps, to the general reader are three brief communications by E. Abderhalden, dealing with several aspects of the recent developments in our knowledge of the Chemistry of Albuminoids. One point which is brought out is that recent experiments have established beyond question the capability of modern chemistry of producing synthetically from the elements all the food materials essential for animal nutrition. In this connection it is interesting to note that it is quite unnecessary to carry the synthesis of food materials to the same complexity as that displayed in natural foods, inasmuch as such foods, upon entering the stomach, are in the normal course of events broken down into simpler bodies. From a scientific point of view, it is quite as satisfactory to feed directly these simpler products which result from the normal decomposition of natural food in the animal economy.

Many of the papers presented in this section are naturally of a higher specialized character. We may select just two for citation by titles, the first of these, the contribution from J. M. Nelson and K. G. Falk, *The Electron Conception of Valence;* W. H. Perkin, *Syntheses in the Terpene Group.* This group of organic substances is of the highest importance in connection with the industries of essential oils and the synthesis of rubber which has in these latter days been one of the centers of attention in the chemical world.

IVA. COAL TAR COLORS AND DYESTUFFS.

The little volume which contains the papers on this subject is almost pathetic in its brevity. It is true that the industry of coal tar dyestuffs is not highly developed in this country, yet, in view of the fact that the Congress is international, one would have looked for rather more liberal contributions on a subject of such vast scope as this. The only three papers presented

are ones by F. J. G. Beltzer, on *The Action of Formaldehyde upon Artificial Silk, Cellulose and Starch;* a paper by P. S. Clarkson on *The Development of Hydrosulphites in their Relation to Modern Dyestuffs;* and lastly a paper by T. H. Valett on *The Action of Alakaline Earths on Wool.*

VA. INDUSTRY AND CHEMISTRY OF SUGAR.

In this section a number of valuable papers have been presented, of which only a few can be mentioned here, as follows:

N. Deerr, on *The Status of Cane Sugar Manufacture in the Hawaiian Islands;* O. Fallada and F. Strohmer, *Inversion of Cane Sugar Solutions by Means of Ammonium Chloride;* G. P. Meade, *The Action of Disinfectants on Sugar Solutions;* D. W. Rolfe, *Some Notes on Sugar Manufacture in Porto Rico;* F. Strohmer, *The Influence of Illumination Upon the Growth of the Beet;* C. C. Townsend, *Sugar Beet Growing in the United States.*

VB. INDIA RUBBER AND OTHER PLASTICS.

P. Bary contributes a paper on *The Application of Osmosis in the Deresinification and Regeneration of India Rubber.* E. Markwald reports to the Congress on *The Treatment of Caoutchouc on Plantations.* From this paper we quote the following excerpt which is of very seasonable interest:

"The question whether plantation rubber, under an efficient system of management, is competent to withstand the dangers of competition by synthetic rubber and the possible fall in price in rubber, must on the whole be answered decidedly in the affirmative. There can be no question of any danger to the plantation industry from competition with natural rubber. Much more probable is the opposite condition, of natural rubber being driven from the field by plantation rubber, and in point of fact, the Brazilian government has initiated extensive legislative measures to protect its natural rubber production and place it on a sound basis. A premium of $150,000 for the creation of a blameless standard quality of rubber has been offered for this purpose."

Another paper which deserves at least brief mention is one by L. E. Weber on *The Action of Resins in Vulcanizing Rubber.*

VC. FUELS AND ASPHALT.

The papers submitted under this section fill a volume of very respectable size and in glancing over it, the reviewer feels that it is quite impossible to do justice to it with the brevity which the present occasion imposes upon him. It is hoped to publish several of these papers in *extenso* elsewhere in this and later issues of the SUPPLEMENT. At this time it must suffice to enumerate a few of the most important subjects dealt with. These include *Methods for the Determination of Water in Petroleum and Its Products; The Technical Problems of Coal Preparation; The Better Utilization of Non-Cooking Lowgrade Lignitic Coals; The Beehive Coke Oven in the United States; Neutral Coke; Oil Inspection; The Use of Fuels in the United States Navy; The Oxidation and Deterioration of Coal; The Spontaneous Combustion of Coal; The Alteration of Coal Dust Exposed to the Air; Coal Washing Efficiency; The Production and Utilization of Peat for Power Purposes; Researches of Lubricating Oils: Analysis of Coal and Allied Products.*

VD. FATS, FATTY OILS AND SOAPS.

This is another small volume. We have noted with some interest a paper by Fay & Hamilton on Heavy Metal Soaps. The authors have prepared a number of these and summarized their conclusions as follows:

1. Stearates and oleates of calcium, iron, aluminium, zinc, copper, and lead and stearate of chromium may be easily prepared in aqueous solution from alkali salts of these acids.

2. Oleates of these metals have as a rule lower melting points than the stearates and are darker in color.

3. The stearates and oleates are insoluble in cold petroleum oils, linseed oil and turpentine.

4. All the stearates, and oleates of zinc, form clear solutions in hot linseed oil, turpentine and kerosene oils.

5. The stearates and oleates in weak solutions in kerosene oils separate as precipitates when cold. Calcium stearate and aluminium stearate and oleate in hot strong petroleum oils turn to clear jellies on cooling; the other stearates and oleates under similar conditions form pastes.

A. Heiduschka, of Munich, contributes a paper on the *Unsaponifiable Constituent of Sessom Oil;* F. N. Smalley reports *A Factory Method for the Determination of Total Fatty Acids in Cotton Seed;* from Japan comes a paper by Y. Tanaka, entitled *Studies on Lipase.* It will be remembered that lipase is a ferment or enzyme extracted from the oil seed and having the property of hydrolizing fats and fatty oils; a property which is of significance in connection with the manufacture of soaps.

VE. PAINTS, DRYING OILS AND VARNISHES.

H. A. Gardner reports on the *Rare Paint Oils.* The term includes not only linseed oil, which, as the author points out, is at the present moment rather scarce, but also a number of other important products such as the oil obtained from the soya bean, perilla oil, menhaden oil, corn oil, and cottonseed oil, Chinese wood oil, resin oil and mineral oil. The author has made a number of exposure tests with wooden panels painted with paints made up with varying percentages of these rare paint oils, and reports upon the results obtained in these tests. One of the longest papers presented to the Congress falls under this section. It is a contribution by L. F. Hawley on *Wood Turpentines, their Analysis, Refinement, Composition and Properties.* This paper amounts almost to a small treatise and is not suitable for abstracting. J. M. Klatz contributes a paper on *Benzole and Coal Tar Distillates and their Application in the Paint Trade.* E. Liebreich discusses the question, *Can a Cover of Paint Exert a Stimulating Influence Upon the Rusting of Iron?* The author has investigated this problem experimentally from the point of view of electrochemistry, and recommends the addition of zinc or aluminium dust, or better still chromium salts, as exerting a beneficial influence upon the electric potential of the iron. So far as the chromium salts, however, are concerned, an objection to these lies in the fact that they retard the drying of the oil.

A very much greater protective action is secured, according to the author, by the addition of suitable alkali compounds, especially alkali amides.

J. Cruikshank Smith and G. de Pierres contribute a paper on the *Technology of Varnish Manufacture with Notes on an Improved Scientific Process.* Maximilian Toch discusses the permanency of paintings. H. Williams reports on modern painting methods of the Navy.

VIA. STARCH, CELLULOSE AND PAPER.

Out of the large number of papers presented in this section we may briefly mention the following: *The Effect of Acidity and Time in the Roasting of Dextrines; Preparation of Chemically Pure Glucose from Commercial Products; Composition of Commercial Glucose; The Unfermentable Residue in Hydrolytic Products of Starch; A Study of some of the Physical Properties of Starches; The Scientific Control of Sulphite Pulp Manufacture; The Effect of Variable Grinding Conditions on the Quality and Production of Mechanical Pulp; Antiseptic Tests of Wood Preserving Oils; The Hydrolysis of Starch by Acids; A New Form of Soluble Starch; The Chemistry of Starch; The Influence of By-Products upon the Development of the Industry of Corn-Products; Commercial Cellulose Chemistry, Particularly Relating to Cellulose Acetate; Breeding Maize for Industrial Purposes.*

VIB. FERMENTATION.

It is not surprising to find that this volume contains a number of important communications from our French contemporaries, with whom fermentation industries are of national importance. Thus, we have a paper from P. Carles on *Moselle and Rhine Wines.* The author, in the résumé of his conclusions, says that both Moselle and Rhine wines have a fairly high percentage of alcohol and a fairly high acidity, and that for this reason they do not entirely satisfy the fastidious connoisseur who, in his estimation, would prefer the French wines, made from grapes grown in a climate peculiarly adapted for viticulture.

Ammann and Lindet have investigated the *Influence of Pressure Upon Alcoholic Fermentation.* E. Barbet reports on a *New Industrial Process for Distilling Maize and Utilizing all the By-products.* F. Bioletti presents a paper on *Sulphurous Acid in Wine Making.* He is, on the whole, in favor of the use of sulphurous acid with proper restrictions. His paper concludes with the words: "Favorable decision with regard to the use of sulphurous acid in wine making does not involve a belief in its indiscriminate or excessive use. It is only by the cautious use of amounts carefully calculated for each case that the full benefits of the practice can be obtained and its dangers avoided."

A. Fernbach discusses *The Determination of the Value of Filter Masses for Beer Brewing Purposes.*

G. Hinard contributes a paper on the *Sterilization of Wines.* We quote the concluding words of his paper: "Sterilization in the cold, by filtration, seems to be the most satisfactory process not only for the treatment of diseased wines, but also for the preservation of wines intended for transportation or for aging in the wine cellar. This method is particularly recommendable in the case of fine wines whose delicate bouquet and hue suffer from the application of a temperature of 60 deg. Cent. (the minimum required for pasteurization). It goes without saying that other beverages also can be treated in the same manner. Cider and beer, for example, are much improved by such filter treatment."

There are many more papers in this section whose mention even must be omitted for lack of space.

VII. AGRICULTURAL CHEMISTRY.

This is one of the heaviest volumes in the set, and there are so many important papers that we can do nothing more here than give a list of some of the subjects treated. Among these are:

The Use of Boron, Aluminium, Sulphate, Manganese and Zinc as Catalytic Fertilizers; Experiments with Reinoculation of Sterile Soils; Concentration of the Soil Solution; The Study of Soil Potassium; The Movement of Soil Moisture; Heredity of Starchiness in Potatoes; The Chemical Composition of Important American Soils; The Extraction of Potassium from Silicate Rocks; The Salines of the United States as a Source of Potassium.

VIIIA. HYGIENE.

This is a small volume, with only five papers. E. Bartow has made a study of *The Efficiency of Calcium Hypochlorite in Treating Turbid Waters.* The tests were entirely satisfactory and the author recommends the use of the hypochlorite under conditions similar to those existing at the locality in which he worked.

H. Hinard reports favorably on the sterilization of turbid waters by filtration with a porous mass, the principal constituent of which is magnesium silicate.

C. T. G. Rogers contributes a paper on *The Application of Chemistry to Industrial Hygiene.* He takes this opportunity to draw attention to the need of research work in the chemistry of contaminated atmospheres.

VIIIB. PHARMACEUTICAL CHEMISTRY.

In view of the great bulk of the material dealt with at the Congress this section must be passed over with a simple mention.

VIIIC. BROMATOLOGY. *(Chemistry of Food Stuffs).*

H. A. Baker discusses so-called "Springers" in canned foods, their cause and prevention. The word "springers" is a term given to cans with bulging ends which contain perfectly sound and sterile food products. They are objectionable because one of the first symptoms of decomposition of the contents of a can is such bulging of the ends; and, therefore, cans which display this objection are apt to be condemned by the housewife, even though, as a matter of fact, the goods contained therein may be sound. The author recommends the following precautionary measures to avoid the formation of springers:

1. Sufficient space must be left in the can to receive the gases which will be formed. This means evenly filled cans in which the exact amount of head space has been determined for each food article and process.

2. This head space must be "exhausted" adequately so that enough vacuum is left to receive the gases that will be formed and still leave the ends of the containers drawn in or under vacuum.

3. Cans, after sealing, must be processed as soon as possible to minimize the formation of carbon dioxide gas, and there should be no undue delay in working the food product through the factory from the beginning of its preparation until it is sterilized.

4. With highly acid food products, the metallic container should have a protective coating of enamel.

F. P. Dunnington, speaking of *The Grinding of Corn Meal for Bread,* says:

"It seems that the work done in refining corn meal is, so far as its use for bread is concerned, not well directed, in that the portion of the grain so removed is the very portion in which rests one of its chief advantages. It is true that meal from whole corn will not keep, under most conditions, more than three or four weeks, but is it not profitable to supply this fresh meal to obtain its several advantages?

"In recent years there has been much and successful endeavor to free wheat flour from all bran and husk, so securing its pure whiteness while losing the advantages of the rougher fiber and ash content. But I think I have shown that similar processes do not improve corn meal, and that there is by this process loss of some of its most valuable constituents.

"It appears from the favor with which oatmeal and many of the numerous breakfast foods are received (so much so, that in some cases these are sold at from three-to five-fold of the price of the grain from which they are made), that there is a craving of many stomachs for rougher food such as stimulates the processes of digestion; and this is certainly in many instances the explanation of the satisfaction with which corn bread is preferred by many as a staple diet.

"But when corn is well matured, kept to thoroughly dry on the ear, and then, as it is needed, ground without heating, by burr stones, slowly turned by a water wheel, it furnishes a sweet, nutty flavored meal, which combines the most valuable of nutrients, and when cooked in the simplest manner, furnishes a food which is to many of mankind very acceptable, and to some, the staple of life."

Other subjects which must be passed over with brief mention are the following: *The Packing of American Sardines; Salmon Canning Industry of North America; Proposed Method for the Estimation of Tin in Canned Foods; The Chemist in the Service of the Packing House; An Investigation of the Manufacture of Tea.* This last paper is interesting in bringing out the international character of this occasion, for the author is Mr. Sawamura, of the College of Agriculture, Imperial University of Tokio. Incidentally, it may be said that not a few of the papers are contributed by Japanese scientists.

To be continued.

Blindfolded Camel Working a Sakiya. Primitive Method Employed for Local Irrigation Throughout Egypt. When Blindfolded the Animal Has Merely to be Started and Will Then Go Round and Round Indefinitely, Believing That Somebody is Just Behind. From Sunrise to Sunset Throughout the Region the Monotonous Creak of the Sakiya is Heard.

Sakiya Worked by Two Cows. The Earthen Jars Fastened Around the Wheel on the Left Empty Themselves Automatically as They Come to the Surface of the Deeply Sunken Well. The Water From the Trough Flows Out Into the Field Under Irrigation, Connecting With a Series of Canals Cut Into the Ground for the Purpose of Distributing the Water.

Local Irrigation in Egypt

Primitive Methods that Persist to the Present Day

By A. W. Cutler

EGYPT is a rainless country. It follows, therefore, that artificial irrigation has always been necessary for the land. The earliest kings of Egypt realized this. We read that Mena, the first king, who reigned 3400 B. C., was alive to the fact that the annual Nile floods were insufficient to properly nourish more than a comparatively small tract of country, owing to much of the water being lost in the Mediterranean Sea. He endeavored to stop this waste as far as possible, and investigations led to the discovery of a depression, 150 feet below the Mediterranean, in the district known as the Fayoum. This depression was connected with the Nile by a canal, and thereafter when the floods came a quantity of valuable water which would otherwise have been lost was put to good use by a network of ditches intersecting the surrounding country.

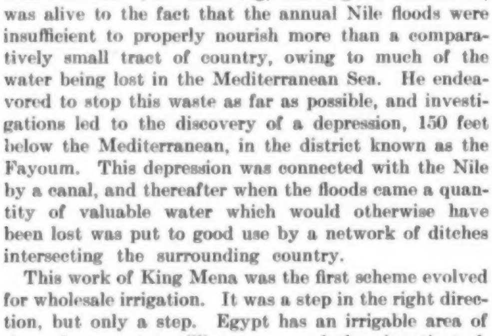
This work of King Mena was the first scheme evolved for wholesale irrigation. It was a step in the right direction, but only a step. Egypt has an irrigable area of six and a quarter million acres, and the gigantic task of making this vast expanse of land perennially productive may be said to have been only just completed by the heightening of the great Assouan dam. This enormous reservoir, working as it does in conjunction with the barrages at Esneh, Assiout and Cairo (the Delta barrage), satisfactorily discounts the absence of rain, and a plentiful supply of water is now assured for the whole of Egypt.

In spite, however, of these marvellous engineering feats, local irrigation has still to be practiced. It constitutes the most important item in the daily life of the fellah—the Egyptian peasant. The four barrages over the Nile merely guarantee an abundant supply of water in the numerous canals intersecting the entire country. This water during the greater part of the year has to be distributed over the fields by local labor. The methods employed are threefold. It is done by the sakiya, the taaboot, and the shadoof.

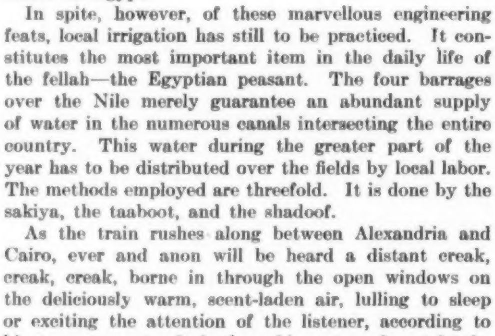
As the train rushes along between Alexandria and Cairo, ever and anon will be heard a distant creak, creak, creak, borne in through the open windows on the deliciously warm, scent-laden air, lulling to sleep or exciting the attention of the listener, according to his temperament. It is the sakiya at work out in the fields. Usually close to one of the canals, you see these primitive inventions constantly all the way up to Cairo. And you will note them by the banks of the Nile from Cairo to Assouan, a distance of 600 miles. Near Luxor and farther south, where the heat is great even in winter, you will see half naked and sometimes wholly naked boys engaged in the monotonous, unending task of driving the animals bound to these sakiyas. Round and round they go; creak, creak, creak goes the sakiya. You hear it from sunrise to sunset. There is no surer cure for a wornout nervous system than the glorious air of the Nile, and the creak of the old sakiyas.

The construction of the sakiya is very simple. The ends of the trunk of a palm tree rest on two vertical supports of sunbaked bricks. Underneath the trunk in the center is the point of a stout wooden pin, which pierces a cogged wheel, arranged horizontally. The cogs of this wheel fit into the cogs of a similar wheel, placed vertically. A shaft from the latter wheel connects with a third wheel, around which have been fastened a number of inverted earthen jars.

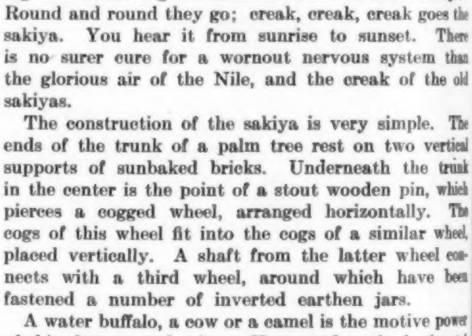
A water buffalo, a cow or a camel is the motive power of this clumsy mechanism. Harnessed to the horizontal wheel they walk round in a circle, and as the wheels revolve the jars descend and ascend a deeply sunken well, emptying themselves automatically into a wooden trough as they come to the surface. The water flows



The Shadoof—the Most Primitive Machine in the World for Irrigating the Soil. It Was in Use Before 3400 B. C. The Lump of Mud at the End of the Pole is Sufficiently Heavy to Lift the Bucket Full of Water from the Well Below. Two or More Shadoofs May be Worked in Series.



The Taaboot, or Archimedean Wheel, Another of the Laborious Devices Employed in Egypt for Local Irrigation. It is Simply a Long Wooden Tube Fitted Inside With a Spiral Arrangement Made of Thin Laths. As the Device Revolves the Water is Fairly Screwed Up from the Canal.



Three Shadoofs on the Banks of the Nile Operating in Series. The Man at the Top Empties his Bucket Into a Canal, Which in Turn Feeds Other Similar Canals, Intersecting the Surrounding Land. Thus the Land is Literally Irrigated by a Bucketful of Water at a Time.

Sakiya on the Banks of the Nile. A Cog-wheeled Arrangement Revolves a Wheel, Around Which Are Fastened Earthen Jars. These Descend and Ascend a Well, Emptying Into a Trough as They Come to the Surface.

Making a Taaboot. It Will be Seen From This Picture That the Water Needed for Irrigation is Literally Screwed From the Canal. This is the Well-known Principle of the Archimedean Screw.

out into the field under irrigation, being distributed by a series of grooves, or tiny channels, intersecting the piece of ground.

Very often the animals working these sakiyas are blindfolded. This has the effect of keeping them "on the job," without being driven. Once started, they will go round and round indefinitely, believing, no doubt, that their master is just behind, while, as a matter of fact, he is at work in the fields.

The sakiya of Lower Egypt, always referred to as the water wheel of the Delta, is a somewhat more modern scheme and distributes the water faster than the antiquated sakiya of Upper Egypt. The wheel, which descends the well, is similar in construction to a huge clumsy cart wheel, minus spokes, and hollow from rim to hub. Into one side of this wheel holes are cut a few inches apart, and as it revolves the water enters through these openings, and is discharged after the manner of the old type sakiya, only in greater volume.

Laborious and slow as this system of irrigation is, it is rapid in comparison with the taaboot, or Archimedean wheel. This is simply a long wooden tube, fitted inside with a spiral arrangement, made of thin laths. One end of the tube is fixed in a canal, and the wheel is operated by an iron handle attached to the other end, which is seized by a man sitting on the ground, the tube being turned round and round. As it revolves the water is literally screwed up from the canal. It is conveyed to the field under irrigation in the manner already described.

But by far the most strenuous method adopted by the Egyptians for local irrigation is the shadoof. I feel that I can afford to be dogmatic here, and state positively that the shadoof is the most ancient contrivance in the world still in use. Crude carvings of this most primitive device of primitive man may be seen on the walls of the prehistoric temples around Luxor. It may have been an old invention even in the days of King Mena. Its origin has never been traced.

A child could make a shadoof. A section of a tree trunk, a wooden pin, two long poles, a lump of mud, a piece of cord and a bucket—these are all the materials needed. The tree trunk is fixed in the ground vertically. One of the poles is now adjusted see-saw fashion over the top of the upright trunk, and held in position by means of the wooden pin. At the base of this pole the lump of mud is placed. At the top of the pole the piece of cord is attached, and from it the other pole suspended. At the bottom of this pole the bucket is fastened. There you have your shadoof all ready for work.

The man or boy working the shadoof merely draws down the bucket and sinks it into a deep well dug directly beneath. The lump of mud at the end of the other pole is sufficiently heavy to lift the bucket when full. All that now remains to be done is to empty the bucket into the groove cut for the reception of the water, which is distributed by means of the network of tiny channels.

As in the case of the sakiya and taaboot, the shadoof is usually seen by the side of a canal or the river. Where the banks of the Nile are high, a rising scale of three, four and even five shadoofs may be observed working together in conjunction with one another. The man on the river level empties his bucket into a depression in the bank about even with his head. This water is bucketed up in a similar way by the man above him. The man on the top of the bank now lowers his bucket (assuming there are only three shadoofs in operation) and deposits the water therefrom into the aforementioned groove.

Thus, every single bucketful of water is handled three times before it finally reaches the section of land being irrigated!

Some Physiological Considerations in Lighting Problems*

The Ideal System would be a Combination of Direct and Indirect Lighting

By W. F. Schaller

The importance of physiological considerations in the design of systems of illumination has not generally been realized by engineers. This phase of the problem particularly merits attention in the lighting of libraries, schools, offices, and textile mills, where, very often, the quality and quantity of work done depend directly on eye comfort—or discomfort. The problem, in any case, is efficiency. Efficiency of illumination may be defined simply and specifically by the purpose of illumination, i. e., the end sought is a physiological process—sight.

The eye is a physiological camera. The light flux entering the eye is varied in its physical quantity by the reaction of the eye on the light flux density, in contracting or expanding the pupil, i. e., in changing the size of the aperture. The retina, on the rear interior of the eyeball, is comprised of two classes of nerve terminals, designated as rods and cones, which are sensitive to the light flux which has entered and serve as the origin of the sense of sight. Behind the iris, the muscular sheet which carries and controls the pupil, is a converging lens hung in a circular muscle by whose contraction or distention focus is varied to accommodate for the distance of the objects viewed.

Three theories, those of Hering, Ladd-Franklin and König, are now most generally accepted to account for the phenomenon of sight. As given, the first two are color theories and the third one explains *Seh-schärfe*, the ability of distinction. Prof. Ewald Hering maintains that the retina contains three chemical substances, each of which is capable of two opposed processes, decomposition and recomposition. With the assumption of four primary colors, red, green, blue and yellow, with white and black, one pair such as red and green may act on a substance, red destroying and green building it up. The other two pairs act similarly on the other two substances. A theory advanced by Mrs. Ladd-Franklin of Johns Hopkins University states that the retinal rods are sensitive to white light only and the cones to the colors. Accepting the theory that there are three primary colors, red, yellow and blue[1], she

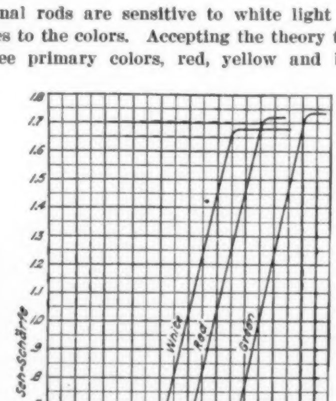


Fig. 1.

says that the cones are composed of three kinds of molecules, each one being sensitive to light of one of the three colors. When light of any one of these colors enters the eye it breaks away or decomposes a number of the molecules sensitive to it, in proportion to its intensity. The violence of the action then is transmitted to the brain as distinctness of vision.

The following explanation of the phenomenon of sight was presented by Dr. Arthur König of the University of Berlin before the Royal Academy of Sciences at Berlin in May, 1897. This scientist made an elaborate set of tests to determine the relation between the ability of perception and the intensity of the illumination. Briefly, his method consisted in using the eye to distinguish characters, similar to those used by the oculist, under varying illumination intensities of the colors white, red, green and blue. The ability to see was measured in some arbitrary units and plotted as *Seh-schärfe* against *Beleuchtung* or illumination, with results as shown in Fig. 1. The following general equation is found to fit the curves:

$$S = a\ (\log B - \log C)$$

where

S is ability to distinguish, *Seh-schärfe*.

B is intensity of illumination.

a is a constant depending on the nature of the light, and is about ten times as great after the bend in the curve as before.

C is a constant inversely proportional to the *Helligkeitswerth*, or "brightness" of the light. Based on these results the logarithmic law of sensation as applicable to the eye was discovered and the following theory evolved: That the rods of the retina are affected by the lower values of light entering the eye and the cones by the higher values. Thus the factor a is smaller when the rods are affected, and larger when the cones come into play. The bend in the curve marks the transition point; which is not sharp, however, since the transfer is more or less gradual and the rods and cones may be active simultaneously. Further, C has

* Reproduced from the *General Electric Review*.

[1] Red, yellow and blue were the three primary colors used by artists, and are sometimes given now as pigment primaries. The light primaries, however, are red, green and violet. The old primaries (red, yellow and blue) were obtained by a negative method, and are really the complementaries of the actual positive light primaries.

two values, depending on whether the rods or cones are affected. This theory is substantiated by tests carried on with a totally color-blind person, whose retina should contain no cones. The results are shown by the dotted lines. It will be noticed that the abscissæ of these curves are plotted to a logarithmic scale. If they had been plotted to a regular scale the result would have been a series of curves of the general shape shown in Fig. 2. Each curve consists of two sections, each a logarithmic curve, the lower one representing conditions when the rods are in use and the upper when the cones are working. The different curves were taken for the various colors of light as indicated in the figure. They have no practical value, but serve simply to bring out the fact that there is a marked change-over from rods to cones (at point *A*), and show the range through which each works.

All are agreed, however, that vision is a result of a destruction of certain retinal elements by the chemical action of the incident light. This destruction induces a nervous impulse which is carried to the occipital lobe of the cerebrum and there sensed. Distinction partially results from differences in light flux density from the objects perceived, i. e., differences in illumination. These may be differences in quality, i. e., in color, or differences in quantity, i. e., in intensity of brightness. As such, distinction includes the effect of shadows as causing the differences in intensity at the edge of objects.

It is the change in pupil opening that, in part, explains the marvelous adaptability of the eye to the enormous range of intensities of illumination met in nature. Under favorable conditions small print may be read by the light of a small candle or by the light of the blazing sun, which has an intensity varying from one thousand foot-candles one hour after daylight, to eight or nine thousand foot-candles at noon. Inherent retinal adaptability, fatigue, and the logarithmic law of sensation also help to account for the wide variation of light which the eye will accept.

Experiment has shown that the sensitiveness of the retina to impressions is enormously increased by protecting the eye from all light. Recently it was found that in the dark the eye increases, during the course of an hour, several thousand fold in sensitiveness. It is a fact that if the eyes are bandaged for twenty minutes they will be able to perceive a glimmer of light that ordinarily is not perceptible. On the other hand, the eye becomes fatigued when the active retinal elements cannot be replaced fast enough for the amount of light flux entering, i. e., the nerves become less sensitive when exposed to high intensity of illumination. The consequence is that a much greater change of intensity of illumination is necessary to produce conscious impression, under circumstances where the eye is exposed. This, of course, is the only condition found, and it becomes necessary for the illuminating engineer to keep his light sources out of the field of vision.

No paper on this subject is complete without a discussion of "glare." In general, glare is discomfort or depression of the visual functions associated with strong light sensation. Glare is experienced when a light source in the field of vision causes discomfort; because, in the attempt to distinguish objects upon which the intensity of illumination is low, the pupil is distended to such an extent that the amount of light flux entering from the exposed source becomes excessive and causes pain. The headlights of a motor car approaching along a straight road do not cause glare, because the eye, in watching it come, has adapted itself to the intensity of the lamps. When the car turns a corner, however, and flashes the lights into the eyes, glare is experienced because the pupils have been wide open in order to allow distinction of objects in the faint light.

[1] This definition of glare is rather narrow, and should perhaps be modified to include the influence of a light source in the field of vision, or any extreme contrast in intensity of illumination which may cause pain or interfere with vision. This must not, however, be interpreted to mean that the excessive intrinsic brilliancy of a light source causes glare, because under proper circumstances glare may be occasioned by the light of a candle. If the headlights of a motor car approaching along a straight road cause discomfort it is either because, when looking directly at them, the pupil cannot narrow sufficiently to shut out excessive light flux, or because the observer is attempting to distinguish objects other than the lights, as, for instance, the outline of the car itself. Glare, when defined as physical discomfort, should probably include also the physical and nervous strain caused by brow puckering when holding the eye fixed on an object, the iris being maintained in a state of constant contraction to exclude the light, and the muscles which carry the eyeball continually trying to turn the eye away from the source of irritation.

Glare may be occasioned by regular reflection from polished surfaces. The avoidance of this becomes a problem of some importance in library illumination, on account of the use of polished tables and the fact that the paper of books and magazines is always more

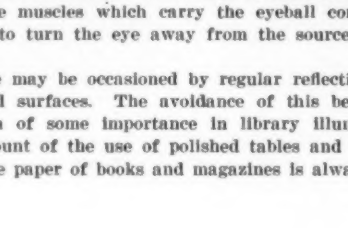


Fig. 2.

or less perfectly glazed. That this form is particularly annoying is because the eye has become habituated through the experience of centuries to light coming obliquely from above. Glare due to a light source above the horizontal is very often prevented by the mechanical construction of the eye and by the use of an eye shade, as the brim of a hat. Nevertheless a light above the horizontal and in the field of vision causes less discomfort than one below. This is a well-known fact, and may be illustrated by referring to theater experiences, the chandeliers and exposed footlights being the sources of light above and below the horizontal. After due allowance is made for the difference in intensity of illumination furnished by the two the result is still marked. This is one of the reasons why reflection from a snow field or sheet of water is particularly distressing. In any case, glare results in an obscuration of vision caused by scattered light in the eye. Dr. Percy W. Cobb, of the N. E. L. A., Cleveland, has made an interesting study of the subject from this side, by considering the extent of the retinal surface stimulated by a side-light and the result of high intrinsic side-light brilliancy. He, with other investigators, came to the conclusion that the glare-effect does not become noteworthy unless the side-light makes an angle of less than twenty-six degrees with the line of vision.

Glare is undesirable, not only on account of its painful physiological effects, but also because its presence always makes necessary a greater intensity of illumination on the work. Steinmetz says, "If points or areas of high brilliancy are in the field of vision, especially if near to the object at which the eye looks, the pupil contracts and thereby reduces the amount of light flux which enters the eye. The same result is produced as if the objective illumination were reduced. The existence of points of high brilliancy results in a great waste of light flux." It has been shown that the presence of a 16-candle-power lamp in the field of vision decreases one's ability to read by approximately thirty per cent. The effect would be more marked if the intensity of the lamp were greater. The same holds true with regard to excessive light on surfaces within the field of vision, as the walls of a room. Thus over-illumination almost always results in glare. Consider the illumination of a printed page. Too bright a light obscures the contrast between the letters and page. No ink is so black that no light is reflected from it. By strongly increasing the intensity of the incident light the increase in the reflection of light from the ink becomes greater in proportion than the increase in reflection from the paper, and hence the contrast which is so essential to clear vision is diminished.

Correct illumination is secured by the use of proper shades for the direction, diffusion and diffraction of the light rays and the proper location of the sources from which they issue. It is interesting to consider some points which tend toward relieving the strain imposed on the eye when working by artificial illumination. Such relief may be obtained, granted that the design of the system is such that a proper amount of light is shed on the work, by subjecting the eye to a more or less regular set of "ocular gymnastics." This may be done by offering a place of rest to the eye when it leaves the work, by having a lower intensity on the walls and ceilings than on the work. A slight movement of the muscles takes place in opening the pupil for the lower light value, and this is reversed when going back to the desk. When this idea is carried to the extreme, however, a distinct effort becomes necessary to adapt the pupil to the large change, and muscular fatigue results. A set of experiments, consisting of periodically raising and lowering the voltage on the lights in a room and so varying the illumination very slightly proved very restful to the eyes. If the eye has been fixed on a number or series of objects of the same shape, size, or color for a length of time, distinct relief may, of course, be obtained by fixing it on something having greatly different properties. As an example of this may be cited the relief experienced when, after reading and keeping one's attention on the black letters on a white page, one's eye is directed toward anything brightly colored. The same principle is involved as when a bank clerk, after having handled flat dry papers, takes a moist round orange into his hand.

It is evident that the physiological peculiarities of the various individuals to be served in any one lighting installation are so varied that, after all, the success of the design depends largely on the judgment of the engineer. After consideration of the points brought out it would seem that an ideal system of illumination would be a combination of indirect and direct, producing a condition of low general illumination with a local higher intensity at the places of work.

[2] There has been a great deal of difference of opinion as to what constitutes "glare." It would appear that the general practice in this country is to consider glare as including the influence of a light source in the field of vision, or any extreme contrast in intensity which may cause pain or interfere with vision. In accordance with this interpretation, the example of the headlights of a motor car approaching along a straight road will be considered as an instance of glare, although not so excessive as would be obtained were the light flashed suddenly into the eyes.

Blue Gelatine-Copper*

Brilliant Colors from the Colloidal Metal

By Prof. W. D. Bancroft and T. R. Briggs, Cornell University

Copper and the copper alloys such as brass and the bronzes lend themselves very readily to artistic decoration by means of colored superficial films or "patinas." Great as is the variety of colors which may thus be imparted to copper, nevertheless a rich and true blue patina for this metal is practically unknown. It was while seeking such a blue surface film that the electrolysis of copper acetate solutions containing gelatine was first performed. One gramme of gelatine was dissolved in 325 cubic centimeters of a 1 per cent solution of cupric acetate and this mixture electrolyzed between carefully cleaned and burnished electrodes of sheet-copper. The electrolysis was continued for five minutes at a cathode (and anode) current density which varied between 0.15 and 0.45 amp dm_2. The process was carried out at room temperature.

The electrolysis performed, the cathode was found to be covered on its inner surface with a thin, pale brown deposit, which, when rubbed with the fingers was seen to possess a peculiar, slippery surface caused by a very appreciable amount of gelatine deposited simultaneously with the metallic copper. No gas became visible at either pole during the passage of the current.

In itself, this pale brown cathode deposit gave no indication of its peculiar properties and it was by chance only that these were discovered. An electrode, freshly coated with a layer of the gelatine-copper was by an oversight allowed to remain in the solution of copper acetate from which the film of metal had just been deposited and the current was turned off. On removing the electrode from the solution, it was noticed that the brown color originally possessed by the cathode film had given place to a purplish blue of extraordinary

* Paper presented at the Eighth International Congress of Applied Chemistry.

brilliance and beauty. This led to further experiments.

A second electrode was then coated with a film of gelatine-copper and, after careful rinsing with cold tap water, immersed in a 5 per cent solution of copper acetate containing no gelatine. Straightway there ensued a remarkable series of color changes upon the surface of the copper deposit; hues of startling evenness and intensity followed each other in regular succession until the electrodes had acquired a magnificent deep-blue coloration. This process we shall speak of as a "development," since it bears a certain resemblance to the development of the silver image in the process of photography.

EXPERIMENTAL.

1. *Effect of Gelatine.*

After the process of development had been discovered, a more systematic study of the formation and nature of gelatine-copper was undertaken. It then became evident that gelatine must be present in the electrolyte and that this colloid exerted a tremendous influence upon the nature of the cathode deposit. The term "gelatine-copper" was thus justified. The optimum gelatine concentration was found to lie between 0.25 and 0.66 per cent. The electrolysis of copper acetate solutions containing no gelatine failed to give the developable films nor was it possible to substitute other hydrophile colloids such as starch or gum-arabic for gelatine or glue.

2. *Nature of the Electrolyte.*

Electrolysis of copper formate, acetate and propionate solutions containing gelatine resulted in cathode films which developed blue in copper acetate although this development was imperfect in the case of the deposits from the formate solution. Copper sulphate solutions of different strengths and varying gelatine content failed absolutely to give developable deposits. Similar results were obtained with solutions of copper nitrate and chloride.

3. *Effect of Temperature.*

Variation of the temperature at which the electrolysis was performed led to interesting results. Between 20 and 40 deg. Cent., the cathode deposit was of the usual pale brown color and gave a more or less satisfactory color-development to blue in copper acetate. At 50 deg. Cent. or at higher temperatures, the cathode deposit was colored a bright red or a brick red and was unaffected by the developing solution. Between 55 degrees and 60 degrees a short electrolysis with a low current density gave a gold-colored but very thin film which had a rather iridescent appearance. These gold and red films can be lacquered with complete success and are interesting in their application to metal-lochromy.

4. *Other Factors.*

The best results were obtained with copper acetate or propionate solutions made up in the proportion of 1 or 2 parts by weight of the crystallized salt to 100 parts of water. The electrolyte should be neutral or at most but very slightly acid. The current density must be low—between 0.15 and 0.45 amp dm.,—and the process need not exceed five minutes in duration. The nature of the metal used as cathode is of little importance as long as the copper solution is not decomposed. Thus with nickel, brass, and platinum, good deposits were obtained as adherent cathode films which developed a good blue color.

5. *The Development of the Blue Color.*

A 5 per cent copper acetate solution containing no gelatine was used as the developing bath throughout this work, although a copper propionate solution may also be employed. Copper formate developer gave less satisfactory results. A large number of other salt solutions were then tried as developers with practically no success. Thus in normal copper sulphate solution a film of gelatine-copper was colored a dull, dark indigo. In N/50 copper sulphate a fairly good blue color was developed although the colors obtained with sulphate solutions are distinctly inferior to those prepared with acetate developer. Very dilute copper nitrate oxidized the film to dark brown copper oxide while a chloride solution spoiled the deposit entirely.

Several oxidizing solutions were next used with negative results. Potassium chromate, bichromate, permanganate, perchlorate, chlorate, and persulphate failed to give even a trace of blue coloration. The films were usually oxidized slowly to brown cupric oxide. Reducing solutions gave no development. The film of gelatine-copper was unaffected by dilute, warm, hydrazine hydrate and underwent accelerated blue development in copper acetate after such treatment.

A solution of sodium acetate gave no blue coloration of the copper film nor was it otherwise with the acetate solutions of other metals. Hence this phenomenon must be a function of the copper contained in the developing solutions.

6. *Reverse Development.*

An electrode, covered with a deep blue film, was immersed in a very dilute aqueous solution of hydrazine hydrate and, in a short time, bubbles of nitrogen began to form on the blue surface. The blue color then slowly faded away, until, passing in the reverse direction through the series of colors previously described, the film of gelatine-copper again took on its original brown color. This process was called a "reverse development."

The reverse development completed, the electrode was rinsed in distilled water and once more immersed in the usual copper acetate developer. The blue color formed again quickly, but was a bit thin and uneven.

If a film of gelatine-copper is allowed to stand undeveloped for several hours, it completely loses its power of developing in copper acetate. This is probably due to its oxidation by the air because it was found that treatment of such a "dead" film with hydrazine hydrate was sufficient to regenerate its powers of development. The same result was obtained with a film after immersion in warm, dilute hydrogen peroxide—no development occurred until the layer of oxide so produced had been reduced with hydrazine.

THEORY AND CONCLUSIONS.

Schützenberger, by the electrolysis of copper acetate solutions, obtained at the cathode a peculiar form of copper; and, being unable to explain its unusual behavior, he announced it as an allotropic modification. Wiedemann incorrectly contended that the new form of copper was really the oxide of that metal, while recently Benedicks has advanced the idea that we have to deal with a solid solution of acetic acid in copper. It can be shown, however, by a careful study of their results and by consideration of the facts of colloid chemistry, that Schützenberger's copper is merely the normal metal in the form of an irreversible colloid gel.

The same conclusion is applicable to the deposits of gelatine-copper described in this paper. The gelatine acts here as the "protecting colloid," migrates by cataphoresis to the cathode, and there inhibits the growth or crystallization of the copper nuclei. Gelatine-copper is an irreversible gel of colloidal copper. The whole phenomenon is but another example of the marked influence of organic and other colloidal substances upon metals prepared by electrolysis, accounts of which have appeared in the recent papers of Müller and Bahntje, Snowdon, and others.

What is the nature and mechanism of the process of the color development? This is indeed a difficult problem, chiefly because of the exceeding small quantities of reacting material of necessity dealt with. The blue, although a superficial color, is nevertheless not the color of a thin film of gelatine or oxide bringing about interference disturbances in the reflected rays of light. Nor does it seem to be the color of a definite chemical compound. The blue layer does contain oxide as is shown by its action in hydrazine and yet it cannot be prepared by any process of simple oxidation. It cannot be produced by the partial coagulation of the copper gel.

It was shown by Wiedemann that Schützenberger's copper possesses the power of absorbing very considerable quantities of copper oxide from copper acetate solutions. This observation furnished the clue to the process of development. The color changes that appear upon the film are the result of *a surface absorption of hydrous copper oxide from the copper solution.* The hydrous copper oxide is present as a suspension in very appreciable quantities in the acetate or propionate solutions, being the product of hydrolytic dissociation. This being the case, we should expect the best development with the acetate solutions and but little color effect with the sulphate and chloride developers.

The reversal of development caused by hydrazine is due to the reduction of the adsorbed oxide. There seems to be a certain definite concentration of oxide in the copper film necessary for the production of a blue color. As the concentration of the oxide increases by continued adsorption, the film passes through the series of colors so distinctive of the development.

In conclusion it can be said in support of this hypothesis that it is in accord with many of the established facts in colloid chemistry and explains in the best possible manner this decidedly obscure phenomenon. Stannic oxide adsorbs gold from suspension and forms the "Purple of Cassius;" under very special conditions colloidal copper adsorbs hydrous copper oxide and similarly gives an intensely colored adsorption compound.

SUMMARY.

The electrolytic production of a form of colloidal copper was performed with certain copper solutions containing gelatine.

This new form of copper develops a remarkable series of colors when immersed in certain copper solutions, a peacock-blue being the finest color obtained.

The process of development is an adsorption of hydrous copper oxide by the surface of the colloid film.

There have been described methods of coloring metal objects gold, golden-brown or red.

A Simple Method for Purifying Drinking Water.*

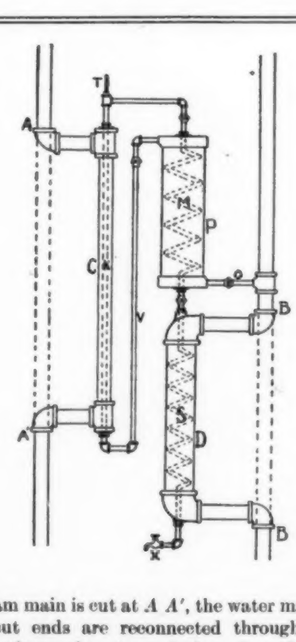
By R. L. Sammis.

WATER for drinking purposes is commonly purified on the small scale by distillation. Distilled water is flat and unpalatable and has to be cooled and stored for use. The possibility of pasteurizing water for drinking purposes, as it flows from the pipes, seems to have attracted little attention. For this purpose, water flowing through a small pipe can be momentarily heated (in a steam jacket or otherwise) to a temperature of 175 to 180 deg. Fahr. (79 to 82 deg. Cent.), by which means disease germs such as those producing typhoid fever, dysentery, etc., are destroyed, while the water under pressure in the pipe does not lose its dissolved gases or its palatability.

The water thus heated can be quickly cooled in the pipe, by means of a cold water jacket. In most buildings, only a small proportion of the water used would require to be heated and cooled for drinking purposes, but the entire quantity used for all purposes could be run through the jacket, to aid in the cooling.

An arrangement of pipes for this purpose can be set up by any pipe fitter at any point where a steam pipe and a water service pipe pass near each other. It is desirable that the steam pressure be uninterrupted, and that the pipe be drained free from condensation. Also the water pipe should be one through which more or less water is flowing continually. The diagram shows the arrangement of the parts.

* Reproduced from the *Journal of Industrial and Engineering Chemistry.*



The steam main is cut at A A', the water main at B B', and the cut ends are reconnected through by-passes which constitute the steam jacket C, and the water jacket D, used for cooling the drinking water. A small stream of water is drawn from the main through valve O, passing through the small jacket P, where it partly cools the water in the interior coil M. From the jacket P, the water flows through V and upward through K, within the steam jacket C, where it is heated to 180 to 200 deg. Fahr. The heated water flows past the thermometer T, through the coil M, and finally into the cooling coil of the water jacket D. The water thus heated and cooled flows out below when the faucet X is opened.

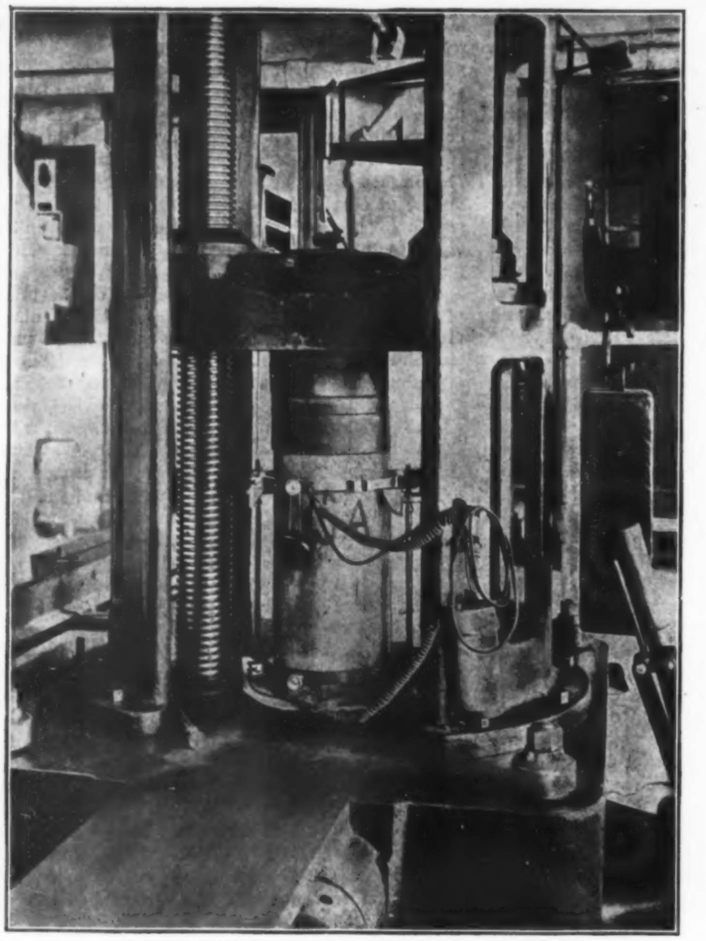
Very efficient cooling can be secured by making coils M and S of tin lined brass pipe. These can be of thin material, since the water pressure inside and outside of them is always alike. In practice, with such an arrangement, no difficulty was found in cooling the water for drinking to within 2 degrees of the temperature of the cooling water in the jacket D. For some reason, not well understood, the water thus heated and cooled under pressure is more palatable to some observers than the untreated water supply.

The water pressure should be about 25 pounds greater in the main B, than the steam pressure in A, in order that the water may not boil in the pipe K, which may be made of ¼ or ⅜-inch galvanized or tinned iron pipe.

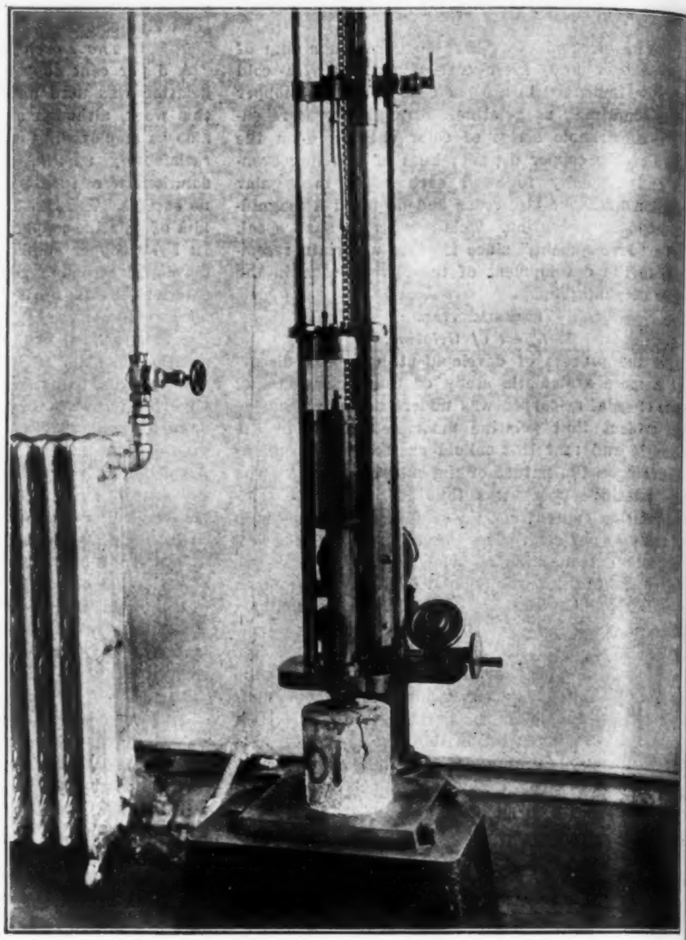
In large office buildings, factories, schools, etc., where steam pressure is maintained throughout the summer, and where water flows continually through the mains for supplying toilet rooms, work rooms, etc., such an arrangement for pasteurizing water for drinking purposes might find useful application.

The amount of steam used in such an apparatus is small, because the regenerative cooler P prevents waste of heat.

For residences, either gas or electric heat might be substituted for steam in such an arrangement as the one described above.



Testing the Strength and Elasticity of Oil-mixed Concrete.



Impact Test on Oil-mixed Concrete.

Oil-Mixed Portland Cement Concrete*

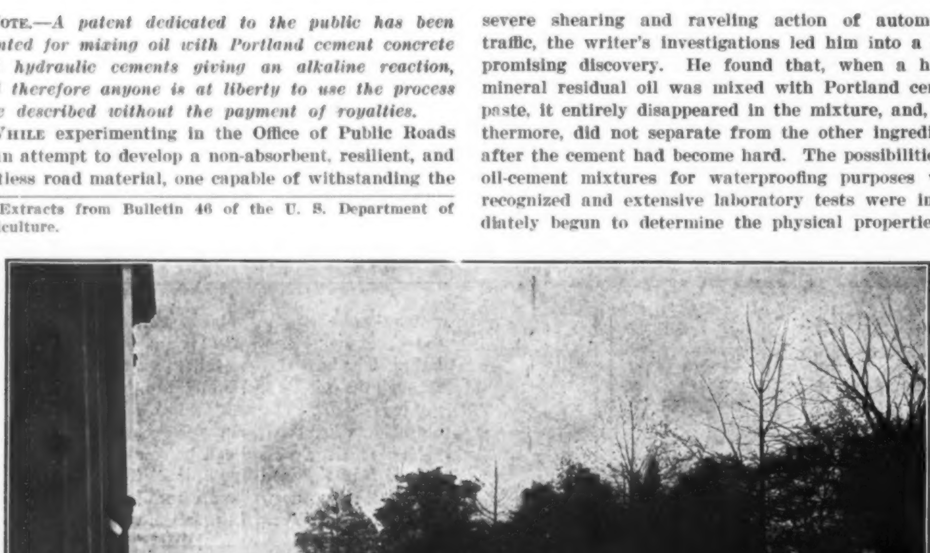
Residual Petroleum for Waterproofing Structures

By Logan Waller Page, Director, Office of Public Roads

NOTE.—*A patent dedicated to the public has been granted for mixing oil with Portland cement concrete and hydraulic cements giving an alkaline reaction, and therefore anyone is at liberty to use the process here described without the payment of royalties.*

WHILE experimenting in the Office of Public Roads in an attempt to develop a non-absorbent, resilient, and dustless road material, one capable of withstanding the severe shearing and raveling action of automobile traffic, the writer's investigations led him into a very promising discovery. He found that, when a heavy mineral residual oil was mixed with Portland cement paste, it entirely disappeared in the mixture, and, furthermore, did not separate from the other ingredients after the cement had become hard. The possibilities of oil-cement mixtures for waterproofing purposes were recognized and extensive laboratory tests were immediately begun to determine the physical properties of concrete and mortar containing various quantities of oil admixtures.

* Extracts from Bulletin 46 of the U. S. Department of Agriculture.



Vaults in the United States Treasury, Made of Concrete Containing Ten Per Cent of Oil.

LABORATORY INVESTIGATIONS.

Many valuable data have been obtained from the investigations. The damp-proofing properties of concrete mixtures containing oil have been demonstrated very definitely by laboratory and by service tests which establish this material as one of great merit for certain types of concrete construction. It has also been shown that the admixture of oil is not detrimental to the tensile strength of mortar composed of 1 part of cement and 3 parts of sand when the oil added does not exceed 10 per cent of the weight of the cement used. The compressive strength of mortar and of concrete suffers slightly with the addition of oil, although when 10 per cent of oil is added the decrease in strength is not serious. Concrete mixed with oil requires a period of time about 50 per cent longer to set hard than does plain concrete, but the increase in strength is nearly as rapid in the oil-mixed material as in the plain concrete. Concrete and mortar containing oil admixtures are almost perfectly non-absorbent of water, and so they are excellent materials to use in damp-proof construction. Under pressure, oil-mixed mortar is very efficient in resisting the permeation of water. Laboratory tests show that oil-mixed concrete is just as tough and strong as plain concrete, and furthermore its elastic behavior within working limits of stress is identical with that of plain concrete. The bond or grip of oil concrete to the reinforcement is much decreased when plain bars are used. Deformed bars, however, and wire mesh or expanded metal will reinforce this material with practically the same efficiency as in ordinary concrete.

SERVICE TESTS.

Two bridge surfaces of oil-mixed concrete were laid during April and May, 1910. In the Borough of Richmond, New York city, during May and June of the same year about 400 feet of street were laid with different kinds of aggregate. About 400 feet of street were surfaced in June, 1910, in the city of Washington. Likewise in the suburbs of Harrisburg, Pa., about one half mile of roadway was laid with a 10 per cent oil mixture. Time alone will show the efficiency of

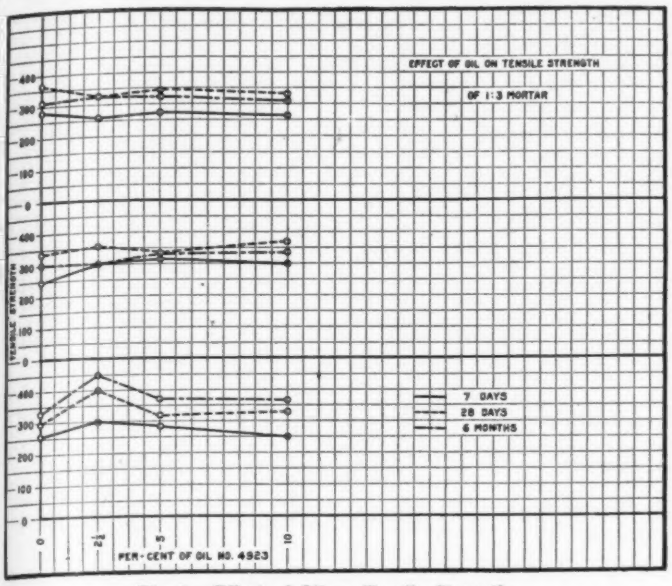


Fig. 1.—Effect of Oil on Tensile Strength.

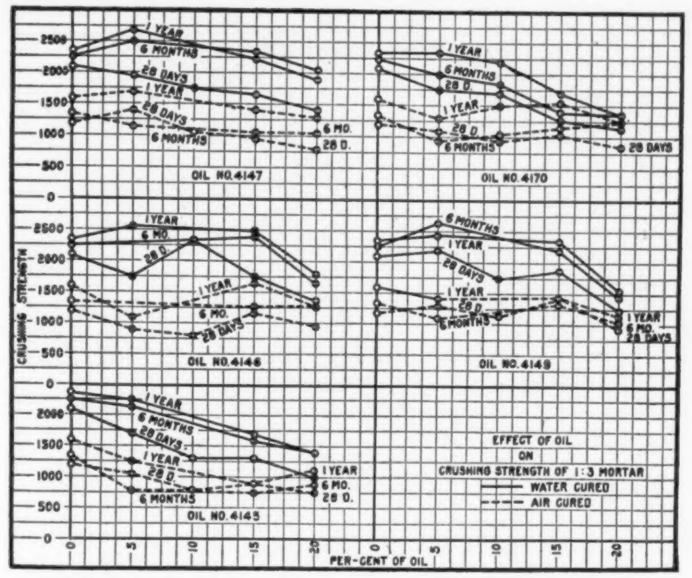


Fig. 2.—Effect of Oil on Crushing Strength of 1:3 Mortar.

type of road surfacing under the different conditions of traffic to which it is being subjected.

Service tests of oil-mixed concrete used as a damp-proofing material have likewise been made. A vault 112 feet long by 18 feet wide in the United States Treasury Department was constructed in the fall of 1910. (See illustrations.) The side walls of this vault contain 10 per cent of oil based on the weight of cement in the mixture. The roof was constructed of ordinary reinforced concrete with about three inches of 10 per cent oil-mixed concrete placed on top. For months the roof of this vault was subjected to several feet head of water without showing any signs of leakage. Another vault in the north end of the Treasury, on account of leaking, has never been available for storing anything of value. Oil-mixed concrete was placed on the roof of this vault, and it is perfectly dry at the present time. Numerous floors in the sub-basement of the Treasury Department and a floor in the Office of Public Roads have been constructed with 10 per cent oil-mixed concrete and have remained absolutely free from dampness.

Several tanks constructed of oil-mixed concrete in the testing laboratory of the Office of Public Roads have remained absolutely water-tight since their completion over a year ago. One of these tanks was made of a mixture of concrete composed of 1 part of cement, 2 parts of sand, and 4 parts of stone, mixed with 10 per cent of oil based on the weight of cement in the mixture. It is used for storing concrete test specimens and is 14 feet long by 5 feet wide by 4½ feet deep. The bottom of this tank is 4 inches thick and is deposited on the cement floor of the laboratory. The sides are 6 inches in thickness and are reinforced with one half inch deformed steel bars. A second tank was built very successfully merely by plastering oil-mixed Portland cement mortar against one half inch mesh expanded metal. Although the sides and bottom of this tank are but 1 inch thick, it is absolutely water-tight against about 2 feet of head.

A very interesting experiment showing the non-absorbent and non-permeable character of oil-mixed mortar when subjected to low pressure was performed in the following way: Four mortar vessels, 8 inches in outside diameter, 2½ inches high, and about one half inch thick, after hardening in moist air for one week, were immersed in water to a depth of about 2 inches. A mortar mixture of 1 part of cement to 3 parts of sand was used. Vessel No. 1 contained no oil in the mixture. About one minute after immersion a damp spot showed on the bottom. After one hour the whole vessel was wet even above the water level, since the water had climbed by capillarity. Within a few days water had penetrated the plain mortar vessel until the water level inside was the same as that outside. The remaining three vessels, made of 1 : 3 mortar and mixed with 5, 10, and 20 per cent of oil, respectively, have remained perfectly dry on the inside during immersion for one year.

All of these experiments have given very encouraging results and point to the use of oil-mixed mortars and concretes as a cheap and effective solution of the problem of waterproofing for a great many types of concrete construction.

Specifications for Fluid Residual Petroleum.

For oil-mixed concrete, petroleum residuum oils conforming to the specifications given below have been found to give good results in both laboratory and service tests.

(1) The oil shall have a specific gravity of not less than 0.930 nor greater than 0.940 at a temperature of 25 deg. Cent.

(2) It shall be soluble in carbon disulphide at air temperature to at least 99.9 per cent.

(3) It shall contain not less than 1.5 nor more than 2.5 per cent of bitumen insoluble in 86 deg. B. paraffin naphtha.

(4) It shall yield not less than 2.5 nor more than 4 per cent of residual coke.

(5) When 240 cubic centimeters of the material is heated in an Engler viscosimeter to 50 deg. Cent. and maintained at that temperature for at least three minutes, the first 100 cubic centimeters which flows out shall show a viscosity of not less than 40 nor more than 45.

(6) When 20 grammes of the material is heated for five hours in a cylindrical tin dish 2½ inches in diameter by 1 inch in height, at a constant temperature of 163 deg. Cent., the loss in weight shall not exceed 2 per cent.

METHOD OF MAKING.

For most purposes where damp-proofing is required 5 per cent of oil based on the weight of cement in the mixture is all that is necessary. A bag of cement weighs 94 pounds, and consequently, for each bag of cement used in the mixture, 4.7 pounds or about 2½ quarts of oil are required.

Let it be supposed that a batch of concrete requiring two bags of cement is to be mixed in the proportions of 1 part of cement to 2 parts of sand to 4 parts of broken stone or gravel, together with 5 per cent of oil. Four cubic feet of sand are first measured out in a bottomless box 12 inches deep and 2 feet on each side. On top of the sand is spread the cement and these materials are mixed together until they appear to be of uniform color. Water is then added to the mixture and the mass again mixed to a mortar of mushy consistency. Five quarts of oil are then measured out and added to the mortar, and the mass again turned until there is no trace of oil visible on the surface of the mortar. Particular care should be taken to continue the mixing until the oil is thoroughly incorporated in the mixture. The oil-mixed mortar is then combined with the stone or gravel previously moistened and the mass is again turned until all of the stone is thoroughly coated with the mortar and the mass is uniformly mixed throughout. Should only oil-mixed mortar be desiréd, the process is similar to that above decribed except that no stone is added.

In a machine mixer the cement, sand, and water are first mixed to a mortar when alternate batches of oil and stone are added until the required quantity of oil is mixed, and then the remainder of the stone is added.

The following table gives the proportions by parts and amounts required of cement, sand, stone, and oil to make a cubic yard of oil-mixed mortar and concrete.

TABLE NO. I.—*Materials Required for One Cubic Yard.*

Proportions by parts.				Cement (barrels[1]).	Sand (cubic yards).	Stone or gravel (cubic yards).	Oil (gallons[2]).
Cement.	Sand.	Stone or gravel.	Oil (per cent).				
1	....	....	3	8.31	....	....	12.1
1	2	....	5	3.32	0.93	....	8.06
1	3	....	5 10	2.48	1.06	....	6.02 12.04
1	4	....	5 10	1.98	1.11	....	4.8 9.61
1	2	4	5	1.57	.44	0.88	3.81
1	2½	5	5 10	1.30	.46	.92	3.15 6.3
1	3	6	5 10	1.11	.47	.94	2.69 5.38

[1] One barrel of cement equals 4 bags.
[2] Oil weighs about 7¾ pounds per gallon.

Vault 112 Feet Long by 18 Feet Wide Constructed in 1910 in the United States Treasury.

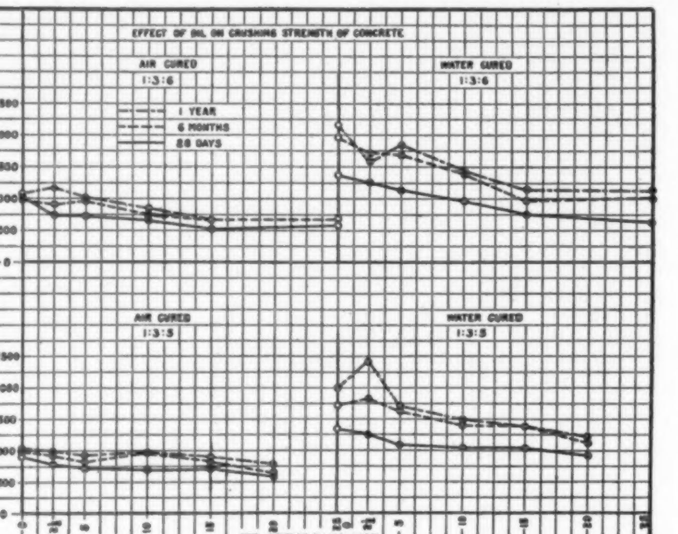


Fig. 3.—Effect of Oil on Crushing Strength of Concrete.

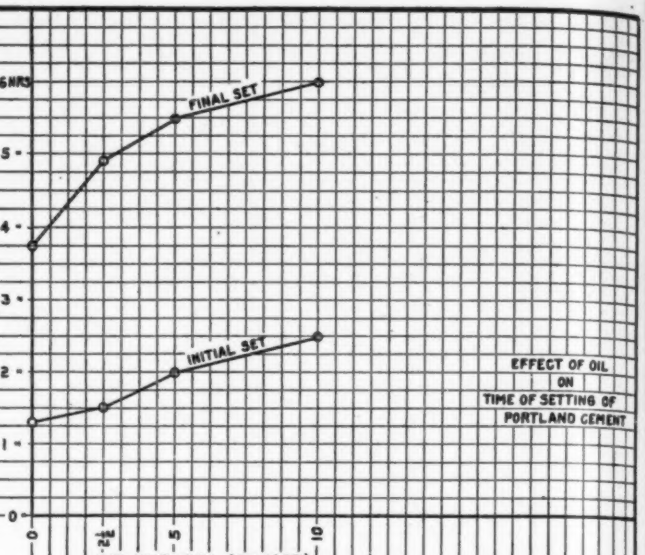


Fig. 4.—Effect of Oil on Time of Setting of Portland Cement.

PHYSICAL TESTS OF OIL-MIXED PORTLAND CEMENT CONCRETE.

The materials used consisted of Portland cement, river sand, crusher-run gneiss, and various kinds of petroleum residuum oils.

The mechanical analysis of the sand and stone used is given below:

TABLE No. II.—*Mechanical Analysis of Sand and Stone.*

Sand.		Stone.	
Sieve No.	Per cent retained.	Sieve No.	Per cent retained.
Inches.		*Inch.*	
[illegible]	3	[illegible]	28.4
[illegible]	11	[illegible]	66.3
10	17	[illegible]	92.1
20	42	[illegible]	98.4
30	66	....	....
40	87	....	....
50	93	....	....
80	96	....	....
100	99	....	....

There were 37 per cent of voids in the sand and 43 per cent in the stone.

The cement passed the specifications of the American Society for Testing Materials.

Various types of oils were used and these are described in Table IV.

TENSILE STRENGTH.

The results below are plotted on Fig. 1. It will be noted that in general the specimens containing oil have a higher tensile strength than those without oil.

TABLE No. III.—*Tensile strength (1:3 mortar, Ottawa sand).*

[Age in days.]

Per cent of oil.	Oil No. 4923.			Oil No. 5053.			Oil No. 4981.		
	7	28	180	7	28	180	7	28	180
	256	296	326	244	331	302	283	376	312
2½........	299	400	449	297	353	298	259	327	323
5........	287	316	372	313	334	325	268	341	321
10........	252	331	300	304	371	330	264	329	319

TABLE NO. IV.—*Analysis of oils used in oil-cement-concrete mixtures.*

Sample No.	4145	4146	4147	4149	4170	4923	4981	5053
Type	(1)	(1)	(1)	(1)	(2)	(1)	(1)	(1)
Character	(3)	(3)	(3)	(3)	(4)	(3)	(5)	(6)
Specific gravity at 25 deg./25 deg. C.	0.924	0.910	0.926	0.923	....	0.945	0.893	0.924
Per cent of loss at 163 deg. C., 5 hours, (20 grammes)	6.86	12.56	7.98	7.02	18.38	1.35	27.17	3.70
Character of residue	(3)	(3)	(8)	(8)	(8)	(8)	(7)	(8)
Per cent of bitumen soluble in CS_2, air temperature	99.99	99.99	99.93	99.95	99.81	99.96	99.95	99.90
Per cent of organic matter insoluble	0.01	0.01	0.07	0.05	0.13	0.04	0.02	0.07
Per cent of inorganic matter insoluble	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.03
Total (per cent)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent of total bitumen insoluble in 86 deg. B. paraffin naphtha	2.23	6.82	10.16	2.24	16.87	3.46	1.00	4.12
Fixed carbon	2.41	3.36	5.11	1.98	....	4.18	1.77	2.82
Specific viscosity, Engler, 50 deg. C.	14.2	6.4	18.2	20.2	....	65.1	2.5	17.4

[1] Fluid residual oil. [2] Cut-back oil asphalt. [3] Fluid, greasy. [4] Fluid, sticky. [5] Fluid, slightly sticky. [6] Semisolid, sticky. [7] Slightly granular, more viscous than original. [8] Fluid, granular in appearance.

Crushing Strength.

Specimens of mortar and concrete containing different percentages of various kinds of oils were molded 6 inches in diameter and 6 inches high. They were bedded in plaster of Paris or blotting paper and were crushed at a speed of 0.152 inch per minute. The curves shown in Fig. 5 give the crushing strength obtained.

It will be noted that the crushing strength is decreased by the addition of oil, but that the decrease is not serious when the amount of oil does not exceed 10 per cent. It will also be noted that oil-mixed cement concrete gains in strength with time in the same manner as untreated concrete—a fact which indicates that the addition of oil to the mixture in small amounts has no disintegrating effect on the cement.

Time of Setting of Portland Cement.

The time of setting is delayed with the addition of oil, as shown by Table No. V, which are plotted on Fig. 4. These results were obtained with the Gillmore needles on specimens subjected to identical conditions while hardening. Five per cent of oil delays the initial set by 50 per cent and the final set by 47 per cent.

TABLE No. V.—*Effect of Oil on Time of Setting.*

Oil No. 4923.		
Per cent of oil.	Initial set.	Final set.
	H. m.	*H. m.*
0	1 18	3 43
2½	1 31	4 56
5	1 57	5 27
10	2 27	5 57

Toughness or Resistance to Impact.

The toughness or resistance to impact was tested on the Page impact machine under the blows of a 10-kilogramme hammer falling on a 5-kilogramme plunger from successively increasing heights of 1 centimeter. The height of the last blow causing failure corresponds to the number of blows. The end of the plunger in contact with the specimen is spherical in shape, with a radius of 3 centimeters. Specimens 6 inches in diameter and 6 inches high were tested after first bedding them in plaster of Paris before mounting on the anvil of the machine. The following results show that the

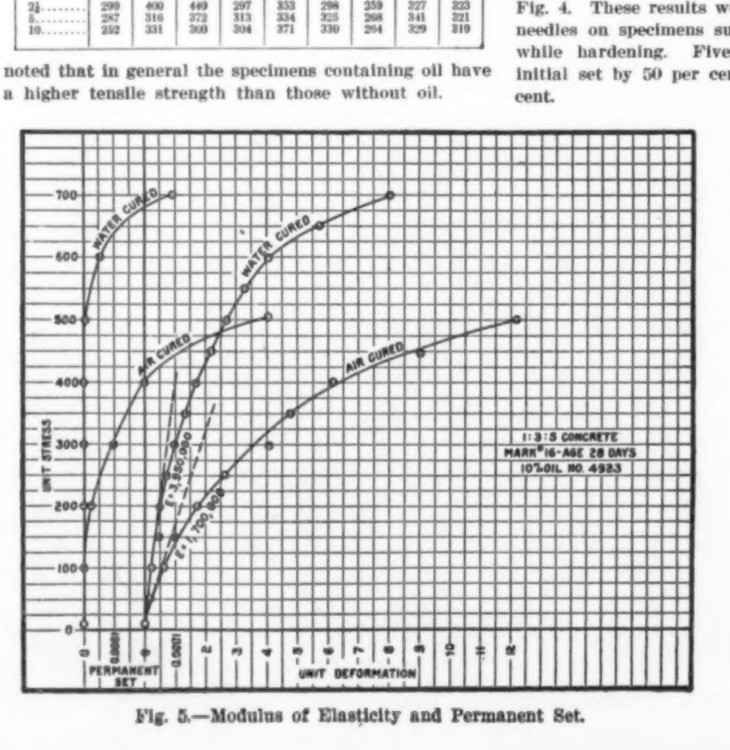


Fig. 5.—Modulus of Elasticity and Permanent Set.

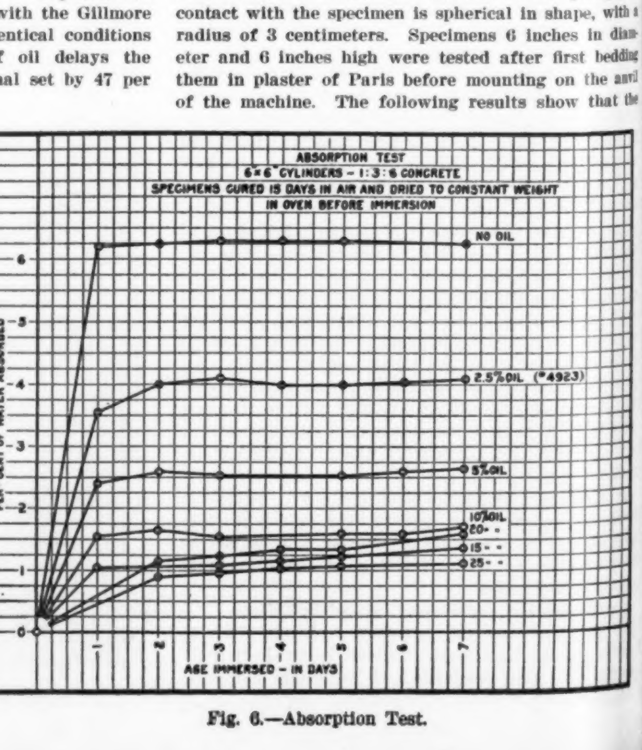


Fig. 6.—Absorption Test.

toughness of concrete is very little influenced by the addition of a small amount of oil to the mixture:

TABLE No. VI.—*Number of Blows Required to Produce Failure.*

Per cent of oil No. 4923.	1:3:5 concrete.		1:3:6 concrete.	
	Air-cured.	Water-cured.	Air-cured.	Water-cured.
0	18	15	15	21
2½	15	33	14	18
5	23	20	15	20
10	13	20	12	21
15	14	20	13	16

A view of the impact machine with a specimen under test is shown on page 188.

Stiffness or Modulus of Elasticity.

For testing the effect of oil on the stiffness of concrete, specimens 8 inches in diameters and 16 inches high were made. The deformations under various loads were measured with a double micrometer screw compressometer of the type described by J. M. Porter in the "Proceedings of the American Society for Testing Materials," Volume X, 1910. Loads were applied in 2,500 and 5,000 pound increments and were released to 500 pounds after each increment of 5,000 pounds, and deformation readings were taken for permanent set. Typical stress deformation and permanent set curves are shown in Fig. 5. In all cases the initial modulus of elasticity was obtained from the slope of the stress-strain curve at its origin. A view of a specimen

TABLE No. VII.—*Initial Modulus of Elasticity (Age 28 Days).*

Per cent of oil No. 4923.	1:3:5 concrete.		1:3:6 concrete.	
	Air-cured.	Water-cured.	Air-cured.	Water-cured.
0	1,300,000	2,550,000	1,300,000	2,200,000
2½	1,350,000	2,700,000	1,000,000	2,400,000
5	1,250,000	2,350,000	850,000	1,900,000
10	1,700,000	3,950,000	1,150,000	1,900,000
15	1,300,000	2,500,000	730,000	2,050,000

mounted in the testing machine with compressometer attached is shown on page 188.

The above results show that oil has little effect on the stiffness of concrete. The increased value of the modulus of elasticity of the water-cured over the air-cured specimens is as marked in the oil-mixed as in the plain specimens. Tests at one year, although not here recorded, show that oil-mixed concrete gains as much in stiffness with age as the plain concrete does.

Absorption.

The resistance of concrete to the penetration of moisture is measured by its absorptive qualities. To test the absorption of oil-mixed concrete compared with plain concrete, cylindrical specimens 6 inches in diameter and 6 inches high were dried to constant weight in an oven, after being cured for 15 days in air. They were then immersed in water and weighed from time to time. The results of these tests are plotted on Fig. 6. It will be seen that the oil greatly decreases the percentage of absorption; the cylinder containing 10 per cent of oil absorbed 1.7 per cent of water, based on the dry weight, while the cylinder containing no oil absorbed 6.25 per cent.

Permeability.

To investigate permeability, specimens 3 inches in thickness and 6 inches in diameter were molded with a surrounding ring of 1 : 1 mortar. Before testing, the top and bottom surfaces were chipped off in order to eliminate the waterproofing effect of the rich surface layers. Plain 1 : 3 mortar at the age of 28 days under 30 pounds' pressure became damp after half an hour. Under 40 pounds' pressure the leakage amounted to 146 cubic centimeters after 24 hours' application. Specimens containing 5 and 10 per cent of oil No. 4923 remained perfectly tight under 40 pounds' pressure.

All permeability specimens made of gravel concrete and containing admixtures of oil have remained perfectly tight under 40 pounds' pressure per square inch. Some of the plain gravel specimens made to compare with the oil-mixed specimens leaked, while others remained tight. Broken-stone concrete made with a very inferior grade of crushed gneiss is not perfectly water-tight under pressure at early periods. After storing for one year, however, even this inferior grade of oil-mixed concrete gives indications of being much less permeable than plain concrete.

SUMMARY OF CONCLUSIONS.

The following conclusions as to the effect of the oils used in cement and concrete may be drawn from the investigations carried out:

(1) The *tensile strength* of 1 : 3 oil-mixed mortar is very little different from that of plain mortar, and shows a substantial gain in strength at 28 days and 6 months over that at 7 days.

(2) The *times of initial and final set* are delayed by the addition of oil; 5 per cent of oil increases the time of initial set by 50 per cent and the time of final set by 47 per cent.

(3) The *crushing strength* of mortar and concrete is decreased by the addition of oil to the mix. Concrete with 10 per cent of oil has 75 per cent of the strength of plain concrete at 28 days. At the age of one year the crushing strength of 1 : 3 mortar suffers but little with the addition of oil in any of the amounts up to 10 per cent.

(4) The *toughness* or resistance to impact is but slightly affected by the addition of oil in amounts up to about 10 per cent.

(5) The *stiffness* of oil-mixed concrete appears to be but little different from that of plain concrete.

(6) *Elasticity.*—Results of tests for permanent deformation indicate that no definite law is followed by oil-mixed concrete.

(7) *Absorption.*—Oil-mixed mortar and concrete containing 10 per cent of oil have very little absorption and under low pressures both are waterproof.

(8) *Permeability.*—Oil-mixed mortar containing 10 per cent of oil is absolutely water-tight under pressures as high as 40 pounds per square inch. Tests indicate that oil-mixed mortar is effective as a waterproofing agent under low pressures when plastered on either side of porous concrete.

(9) The *bond tests* show the inadvisability of using plain bar reinforcement with oil-concrete mixtures. The bond of deformed bars is not seriously weakened by the addition of oil in amounts up to 10 per cent.

The Research Corporation*

An Experiment in Public Administration of Patent Rights

By F. G. Cottrell, Ph.D.

SOME seven years ago the author while working in the University of California on a set of problems in sulphuric acid manufacture came upon certain phenomena which promised to lead to important improvements in the electrostatic collection of smoke and fumes from chemical and metallurgical plants. He was at once confronted by the old dilemma of adjustment between academic and commercial activities, as only through direct construction and study of installations on a commercial scale did it seem possible to develop into full usefulness the inventions involved.

Finally with the help, both personal and financial of Prof. Edmond O'Neill of the Chemistry Department, and Dr. Harry East Miller and Mr. E. S. Heller, both alumni of this department of the university, the commercial development of the project was undertaken and patents secured, the understanding among those thus actively concerned being that when the receipts from the business should have repaid the initial investment with reasonable interest at least a considerable portion of the patent rights should be turned over to the University of California or some other public institution to be administered as the nucleus of a fund for the promotion of research it being also hoped that this might set a precedent and stimulate similar contributions from others.

The business and technical development of the project struggled through and over many difficulties and disappointments for the first few years, but with a constantly growing scale of operation, and it was not until the fifth year of the work that the latter repaid what the organizers had spent upon it.

It is not the purpose here to enter upon the technical details of the inventions involved as the early history of these was published a years ago[1] and has since been extensively abstracted in other journals. A further supplementary account and discussion was also given at the annual meeting of the American Institute of Mining Engineers last February and two papers on the latest development of the subject are being presented before other sections of this Congress.

Merely as an index to the practical significance which the work has already attained, suffice it to say that installations made under these patents have now been in commercial operation for over five years, and the largest of these have been on a scale representing a construction cost of over $100,000 each. The first were in the far West, but several are now in operation or under construction in and about New York city.

By the time the work had thus reached a self-supporting basis, its significance was felt to have broadened to a degree which made its control by a local institution such as a single university inexpedient as the fullest success of such a movement is inevitably conditioned upon its being most broadly representative of the common interests of those whose co-operation and support it aspires to secure. Through Director J. A. Holmes of the U. S. Bureau of Mines, who had taken a very helpful interest in the work, it was brought to the attention of the Smithsonian Institution nearly two years ago, the informal discussion which followed resulting last October in a formal offer of the patent rights to the institution. The only condition qualifying this offer was that these patent rights should be given an adequate business administration and the proceeds be devoted to furthering scientific research.

In December last, after careful consideration and discussion with the prospective donors and under their hearty indorsement, the Board of Regents of the Smithsonian Institution adopted the following resolutions:

RESOLVED, That the Board of Regents of the Smithsonian Institution do not deem it expedient for the institution to become the direct owner of the proposed gift of royalty-bearing patents;

RESOLVED FURTHER, That the Board of Regents of the Smithsonian Institution decide that the institution may properly accept a declaration of trust from the owners of the patents to hold and operate the same in the interests of the institution, and to pay over to the said institution the net profits therefrom.

and further authorized its Executive Committee and its secretary, Dr. Charles D. Walcott, to co-operate with those from whom the offer had come in the organization of either a subsidiary or an independent board of trustees or directors to conduct the business side of the project.

In elaborating this plan, the organizers have tried to study carefully both the economic and academic needs which it was intended to subserve. The following are among the considerations which have perhaps had most to do in determining the form and policy of the new organization as finally constituted.

During the last few years the rapid growth of engineering and technical education, coupled with a general awakening to the commercial importance of research in the industries, has brought about a persistent demand the world over for closer and more effective co-operation between the universities and technical schools on the one hand and the actual industrial plants on the other.

The value to both sides from such co-operation is to-day generally conceded, but as to the most expedient methods of its accomplishment opinions differ, and we are still in the experimental stage of working out the problem.

One solution which has been extensively applied consists in the universities and schools permitting and even encouraging the members of their teaching staffs to go into private consulting practice. Another form of co-operation is seen in the industrial fellowships recently established at several universities, through which their laboratories undertake the investigation of certain problems for individual commercial firms or organizations, the latter bearing the expenses and receiving the first fruits of the investigations, but under restrictions as regards final publication and use, intended to justify the universities or technical schools in taking their part in the work.

While these and similar methods now in use bring about the desired co-operation, it has been felt by some that they are open to the objection of introducing too direct business relations between the academic institutions or the members of their faculties and individual financial interests. As still another alternative, intended particularly to meet to some degree at least this last objection, the Research Corporation has been organized.

Briefly stated, this latter is a board of administration, whose work is to guide the development of such

*Paper presented to the Eighth International Congress of Applied Chemistry.

[1] The Electrical Precipitation of Suspended Particles. SCIENTIFIC AMERICAN SUPPLEMENT, September 30th, 1911, p 215.

patents as may be turned over to it, and finally market them, the net profits from all such business being devoted to scientific research "by contributing the net earnings of the corporation . . . to the Smithsonian Institution and such other scientific and educational institutions and societies as the Board of Directors may from time to time select, in order to enable such institutions and societies to conduct such investigations, research and experimentation." Under this system, it will be noticed, a part at least of the financial returns of the scientific investigations of our academic laboratories automatically goes back to them for aiding further investigations.

But this represents only one side of the good which the plan aims to accomplish. Conservation has of late become a word to conjure with, and all manner of economic wastes are very properly receiving a too-long delayed attention. The men in our universities and colleges have been among the first and most effective in promoting the general conservation movement, yet there is what we may term an intellectual by-product of immense importance, a product of their own activities still largely going to waste. This is the mass of scientific facts and principles developed in the course of investigation and instruction which, through lack of the necessary commercial guidance and supervision, never, or only after unnecessary delay, reaches the public at large in the form of useful inventions, and then often through such channels that the original discoverers are quite forgotten.

The Research Corporation was primarily intended to serve the ever-growing number of men in academic positions who from time to time in connection with their regular work evolve useful and patentable inventions, and without looking personally for any financial reward would gladly see these further developed for the public good, but are disinclined either to undertake such development themselves or to place the control in the hands of any private interest.

During the process of organization, however, it became evident that the class of donors of patents to the cause would by no means be limited to men in academic positions, but rapidly extended not only to private individuals outside the colleges but even to large business corporations who often find themselves incidentally developing patents which overrun their own field of activities. Such patents are very apt to get pigeonholed and come to actually stand in the way of true industrial progress, even though their owners may realize that development and use by others would indirectly benefit themselves. As an official of one of the large electrical companies put it: "Any extension of the use of electricity, or even power in general, is pretty sure eventually to mean more business for us through one department or another."

A procedure adopted in academic and public positions by many men in an attempt to bring various inventions before the public and at the same time prevent private monopoly has been to secure patents as matter of record and then throw them open gratis to public use. This procedure received official recognition in the U. S. Patent Act of March 3d, 1883, which authorizes the remission of all Patent Office fees to Government officials on patents bearing on their face permission for everyone in the country to use the invention without the payment of any royalty.

Practice has shown, however, that this does not accomplish all that had been hoped for it. A certain minimum amount of protection is usually felt necessary by any manufacturing concern before it will invest in the machinery or other equipment, to say nothing of the advertising, necessary to put a new invention on the market. Thus a number of meritorious patents given to the public absolutely free by their inventors have never come upon the market chiefly because, "what is everybody's business is nobody's business."

If some of these patents, on the other hand, were placed in the hands of such an organization as the Research Corporation, it could study the situation and arrange licenses under fair terms, so as to justify individual manufacturers undertaking the introduction of the inventions, and at the same time would be accumulating from the royalties funds for further investigations.

Motor Car Engineering

Steering Devices

The front road wheels of a car are steered by a hand-wheel of which the position, slope, and general arrangement are dictated by considerations of comfort and not appreciably by the designer's natural bent toward the simplest mechanism. Accordingly, the modern steering system has attained a degree of complexity widely different from the simple tiller-bar which distinguished the early Oldsmobile, Lanchester, and electric cars, or the elementary steering-wheel of the Panhard and de Dion of days gone by. Now that a wide experience of irreversible steering gears of all sorts is available, skill and knowledge have been attained which could eliminate the weaknesses in the old devices and enable designers to revert to the general plan—a move for which there is a particular demand in connection with the car of the near future, the cheap car. Fashion, rather than technical reasons, has led to the changes seen yearly at successive motor shows. Twelve years of experience and twelve years of thought and study, if applied to the working, construction, and material used on the old simple designs, would bring success to such a reversion.

In the car of to-day the steering-wheel is rotated to the right or left, causing a piece of mechanism, inclosed in a box at the foot of the steering column, to move up or down the column. This, in turn, causes a short horizontal shaft, lying across the car, to rock, and the arm fixed on this rocker pushes or pulls in a longitudinal direction a drag-rod which is linked up to the steering axles or stub axles. There are two stub axles, one for each front road wheel, and the two are connected so as to move together by an Ackerman linkage.

Contrast this with the defunct Oldsmobile tiller, which moved the road wheels through nothing but the intermediary of a single bell crank and spring. The latter arrangement was not only simple and satisfactory, but was superior in rapid response, ease of repair and inspection, accessibility, and economy, to the more complicated devices on the modern 200-pound car. Seven or eight thousand miles' use of that car proved that this steering was thoroughly good in principle and satisfactory for any vehicle with a speed not exceeding 27 to 30 miles per hour, while for handiness it rivalled the bicycle in quick response. It was far cheaper, and therefore could be made far better for the same expenditure. It was completely reversible, and therefore could not be subjected to the unknown and unknowable shocks which lower the safety of the ordinary steering mechanism. To-day the exact slope of steering heads could be set so that the degree of effort required to steer should be just comfortable; the extent to which the user likes his steering to be self-centering is known, and also the effects of road camber, and the dangers which may arise from the largest road obstacle, such as a deep rut or a brick in the path. If it is ever to be hoped that the vanity of desiring to own an 8-horse-power car which looks like a big vehicle will disappear, it will be practicable so to design the small car that it will be a genuine small car design, and much that has been written about cheap motoring and how to get it will bear fruit.

That mechanism situated in a box at the foot of the steering column is perhaps the detail about which most users are exceptionally ignorant, and this in itself is a fact of some importance when it is realized that a large expenditure of ingenuity is made on the different devices employed without apparently affording to any one any increased satisfaction or advantage, since all steering systems appear to be reasonably satisfactory and none pre-eminent. In one case the rotation of the hand-wheel causes a large nut to move up or down on a thread cut on the column; this nut presses or pulls on a projection from the rocker shaft, the arm of which actuates the drag-rod and the wheel. In another instance a similarly situated thread on the column gears into the teeth of a sector which is keyed to the rocker shaft, and so gives it the to-and-fro motion which the drag-rod transmits. In yet another there are a couple of cams at the foot of the column operating push-rods which control a rocker-bar, as before. A fourth example is that in which a pinion at the bottom of the column works a rack which is guided to move in and out in the desired longitudinal direction. In all of these, as well as in the many other systems, easing of the muscular effort of the steersman is obtained by a demultiplication of the steering-wheel movement, while reduction of nervous fatigue is obtained by so devising the relation of parts that the road wheels are not much or at all, deflected by obstacles and nuts. It is in every case necessary to introduce one hinged or elastic member which allows the coach springs of the car to yield and move without this movement producing any deflecting effect whatever in the steering. Less important is the self-centering arrangement whereby the road wheels, when deflected to negotiate a turn, tend of their own accord to resume a straight course; the weight of the car is usually employed to do this by the use of raked steering heads. Lastly, there is the necessity for the road wheels being trained through an angle which is not the same for each wheel if neither is to scratch along the ground sideways.

The junior motorist is often very critical of that small free angular movement which he finds at the hand-wheel of a new car. He is wrong. That back lash will save him much effort and much nervous strain as soon as he has thoroughly learnt that it exists. Within the limits of that free angular movement the road wheels steer themselves in many well-made cars, and the driver is spared the trouble of constantly moving his wheel about. This must be learnt, just as one must learn that complete irreversibility is bad for another reason, namely, that the presence of some yield avoids breakages.—*London Times.*

Trade Notes and Formulæ

Recipes for White Polishing Varnishes.—1. One hundred parts, by weight, of sandarac, 1,000 parts 96 per cent alcohol, 100 parts Venice turpentine.

2. Three hundred and ten parts, by weight, of sandarac, 125 parts mastic, 1,250 parts 96 per cent alcohol, 75 parts Venice turpentine.

3. One hundred and twenty parts, by weight, of sandarac, 150 parts bleached shellac, 1,200 parts 96 per cent spirit, 100 parts Venice turpentine.

4. Two hundred parts bleached shellac, 1,000 parts 95 per cent alcohol, 100 parts Venice turpentine.

5. Three hundred parts Manila copal, spirit soluble, 100 parts sandarac, 1,500 parts 96 per cent spirit, 120 parts Venice turpentine.

6. One hundred and fifty parts soft Manila copal, spirit soluble, 150 parts pale rosin, 1,200 parts 96 per cent alcohol, 100 parts thick turpentine.

If it is desired to impart a special gloss to the varnished surface, it should be polished, after the last coat has dried, with some alcohol and linseed oil.—*Neueste Erfindungen und Erfahrungen.*

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The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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